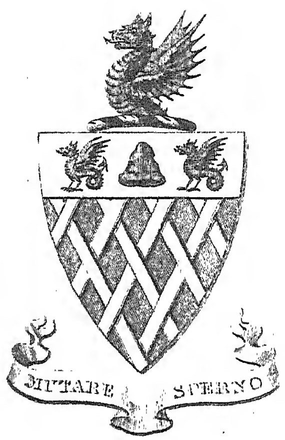
MUTARE SPERNO

BULLETIN

OF THE

BOTANICAL DEPARTMENT, JAMAICA.

EDITED BY

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SOIL FERMENTS IMPORTANT IN AGRICULTURE.

By Dr. W. H. Wiley, Chief of the Division of Chemistry, U. S. Department of Agriculture, in *Year Book of U. S. Dept. of Agriculture for 1895.*

(Continued).

THE STORAGE OF NITRATES.

Attention has already been called to the fact that the activity of the nitrifying ferments in a soil is, as a rule, greater than the needs of the growing crop. For this reason the waters of drainage are found to be more or less impregnated with nitrates. The sea is eventually the great sorting ground into which all this waste material is poured. The roller processes of nature, like the mills of the gods, grind exceedingly slow and small, and the sea becomes the blotting cloth by which the products of milling are separated and sorted out. Not only do the drainage waters carry nitrates, but also potash, phosphoric acid, lime, and other soluble materials of the soil. As soon as this waste material is poured into the sea, the process of sifting at once begins. The carbonate of lime becomes deposited in vast layers or by organic life is transformed into immense coral formations or into shells. Phosphoric acid is likewise sifted out into phosphatic deposits or passes into the organic life of the sea. Even the potash, soluble as it is, becomes collected into mineral aggregates or passes into marine animal or vegetable growth.

All these valuable materials are thus conserved and put into a shape in which they may be returned sooner or later to the use of man. In the great cosmic economy there is no such thing as escape of any valuable material from usefulness. The nitrates which are poured into the sea are sooner or later absorbed by the seaweed or other marine vegetation, or served for the nourishment of the animal life of the ocean. It is highly probable that the great deposits of nitrates found in certain arid regions, notably in Chile, are due to the decomposition of marine vegetation. There must be present in the sea vast fields of vegetation which, growing in water largely impregnated with nitrates, becomes highly charged with organic nitrogenous matter. In the changes of level to which the surface of the earth is constantly subjected, the depths of the sea often becomes isolated lakes. In the

evaporation of the water of these lakes, such as would take place in arid regions, immense deposits of marine vegetation and common salt would occur. In the oxidation and nitrification of this organic matter due to fermentative action, the organic nitrogen would be changed into the inorganic state. In the presence of calcareous rocks, the nitrate of calcium would be formed, which, finally, by double decompositions, would result in the formation of nitrate of soda, the form in which these deposits now exist. The fact that iodine is found in greater or less quantity in these deposits of soda saltpetre, is a strong argument in favour of the hypothesis that they are due to marine origin. Iodine is found only in sea and never in terrestrial plants. Further than this, attention should be called to the fact that these deposits of nitrate of soda contain neither shells nor fossils, nor do they contain any phosphate of lime. It is hardly credible, therefore, that they are due to animal origin. The activity of ferments in these great deposits of marine plants, although taking place perhaps millions of years ago, has served to secure for the farmers of the present day vast deposits of nitrate of soda, which prove of the utmost value in increasing the yield of the field. To every quarter of the globe where scientific agriculture is now practised these deposits are sent. They are of such vast extent that it is not likely they will soon be exhausted, and the labours of the agriculturist for many hundreds of years to come will continue to be blessed by reason of the activity of the insignificant microscopic ferments which plied their vocation in past geological epochs.

Because at the present time there are known deposits of marine vegetation undergoing nitrification, is no just reason for doubting the accuracy of the above mentioned hypothesis. Our geologists are not acquainted at present with any locality in which deposits of phosphate are taking place, but the absence of the process can not be used as a just argument against any of the theories which have been proposed to account for the immense deposits of this material which are found in various parts of this and other countries. Another illustration of this point may be found in the coal deposits. The environment which determines the geologic conditions now is not favorable to the development of large quantities of organic matter from which coal might be produced by changes in the level of the earth's surface In fact, all the teachings of palæontology show beyond a doubt that life in the past geological ages was on a far larger scale than at present. In those remote times the mean temperature of the earth's surface was very much greater than it is at the present time. There are many indubitable evidences of the fact that high equatorial temperatures prevailed even at the poles, while the present tropic and temperate zones were probably too warm for any forms of life which now exist. The fossil remains of animals and plants of those ages show the gigantic scale on which all animal and vegetable life was formed. When crocodiles were nearly 70 ft. in length and dragon flies 3 ft. long, it is not surprising that both terrestrial and marine vegetation existed in a far more exuberant form than at present. The dense terrestrial vegetation which made the coal deposits possible were doubtless equaled by marine vegetable growth capable, by oxidation under favorable circumstances, of forming the vast deposits of nitrates which have been discovered in various parts of the world. The depression of the surface

of the land which enabled the coal measures to be developed beneath the surface of the sea, was doubtless compensated for by the elevation of the marine forests into a position favouring the deposits of nitrates. The wonderful conservative instincts of nature are thus demonstrated in a most remarkable manner in restoring to the fields the nitrates leached therefrom in past ages.

GENESIS OF GUANO.

The fermentative action of germs in the production of nitrates on a small scale and their storage to a limited extent are found going on in many caves at the present time. In these localities large numbers of bats formerly congregated, and the nitrogenous constituents of their dejecta and remains, collecting on the floors of caves practically devoid of water, have undergone nitrification and become converted into nitric acid. In a similar manner the deposits produced in rookeries, especially in former ages, have been converted into nitric acid and preserved for the use of the farmer. The well known habits of birds in congregating in rookeries during the nights and at certain seasons of the year tend to bring into into a common receptacle the nitrogenous matters which they have gathered and which are deposited in their excrement and in the decay of their bodies. The feathers of birds are particulary rich in nitrogen, and the nitrogenous content of their flesh is also high. The remains of birds, especially if it take place in a locality practically excluded from the leaching action of water, serves to accumulate vast deposits of nitrogenous matter, which is at once attacked by the nitrifying ferments. If the conditions in such deposits are particularly favourable to the process of nitrification, the whole of the nitrogen, or at least the la ger part of it which has been collected in these debris, becomes finally converted into nitric acid, and is found combined with appropriate bases as deposits of nitrates. The nitrates of the guano deposits and of the deposits of caves, as has already been indicated, arise in this way. If these deposits be subject to moderate leaching, the nitrates may become infiltered into the sorrounding soil. The bottoms and surrounding soils of caves are often found highly impregnated with nitrates.

IMPREGNATION OF SOILS WITH NITRATES.

When, on the other hand, these deposits take place in regions subjected to heavy rains, the nitric acid which is formed is rapidly removed, to be returned to the ocean and begin anew the circuit of life which will finally restore it to the land. By reason of the accumulation of nitrogenous matters in tropical regions, especially where there is a deficient rainfall, it has been found that the soils of those regions contain a very much larger percentage of nitrates than is found, for instance, in the soils of the United States. These nitrated soils are very abundant, especially in Central and South America, where they cover large surfaces. In these soils the nitric acid, as a rule, is found in combination with lime, while in the purer deposits of nitric acid it is almost constantly found in combination with soda. In some South American soils as much as 30 per cent. of nitrate of lime has been found. Not only birds serve thus to secure deposits of nitrogen, but large quantities of guano rich in nitrates have their origin in the debris of insects, fragments of elytra, scales of the wings of butterflies, and other animal matters which are often brought together in quantities of millions of cubic metres. The products of nitrification in these deposits may also be

absorbed by the surrounding soils. Some localities produce such great quantities of nitrate of lime (which is a salt easily absorbing water) as to convert the soil in their immediate neighbourhood into a plastic paste. In all the deposits such as are described above are found large quantities of phosphoric acid and sufficient remains of animal life to show in a positive manner their origin. It is thus seen that there is a very marked difference between the character of the deposits of nitric acid due to terrestrial animal origin and those which have been derived from a marine vegatable source. An economic observation of some importance may be made here, viz.: To the effect that when in the future the deposits of nitrate of soda due to marine origin are exhausted, it may still be possible to keep up the supply demanded for agricultural use by leaching the highly impregnated soils above mentioned and thus securing the nitric acid in a form sufficiently concentrated to make its transportation profitable.

PROPERTIES OF NITRATE OF SODA

Practically the only form of oxidised nitrogen which is of commercial importance from an agronomic point of view, is sodium nitrate, commonly known in commerce as Chile saltpetre. The nitrate of potash, a nearly-related salt, is also of a high manurial value, but on account of its cost and the importance of its use in the manufacture of gunpowder, it has not been very extensively applied as a fertilising material. When Chile saltpetre is applied to a growing crop it becomes rapidly dissolved, especially at the first fall of rain or by the moisture normally existing in the soil. It carries thus to the rootlets of plants a supply of nitrogen in the most highly available state. There is, perhaps, no other kind of plant food which is offered to the living vegetable in a more completely predigested state and none to which the growing plant will yield a quicker response. By the very reason of its high availability, however, it must be used with the greatest care. A too free use of such a stimulating food may have, in the end, an injurious effect upon the crop, and is quite certain to lead to a waste of a considerable portion of expensive material. For this reason, Chile saltpetre should be applied with extreme care in small quantities at a time, and only when it is needed by the growing crop. It would be useless, for instance, to apply this material in the autumn with the expectation of its benefiting the crop to a maximum degree the following spring. If the application of the manure should be made just previous to a heavy rain, it is not difficult to see that nearly the whole of it might be removed beyond the reach of the absorbing organs of the plant.

DECOMPOSITION OF SODIUM NITRATE.

The molecule of sodium nitrate is decomposed in the process of absorption of the nitric acid. The plant presents a selective action to its constituents, the nitric acid entering the plant organism and the soda being rejected. Soda, however, may not be without its uses, for doubtless being at some time in a practically nascent or hydrated state, it may play a *role* of some considerable importance in decomposing particles of minerals containing phospheric acid. It is probable that the decomposition of the sodium nitrate takes place in the cells of the absorbing plant. For it is difficult to understand how it could be accomplished externally except by a denitrifying ferment. While the soda itself is, therefore, of little importance as a direct plant food, it can

hardly be dismissed as of no value whatever in the process of fertilisation.

Many of the salts of soda—as, for instance, common salt—are quite hygroscopic, and serve to attract moisture from the air, and thus become carriers of water between the plant and the air in seasons of drought.

The Chile saltpetre of commerce may reach the farmer in the lumpy state in which it is shipped, or finely ground ready for application to the fields Unless the farmer is provided with convenient means for grinding the latter condition is much to be preferred. It permits of a more even distribution of the salt and thus encourages economy in its use.

NEED OF SODIUM NITRATE.

The question of when the soil needs an application of Chile saltpetre is often one of great importance, and the farmer would do well, before applying a great deal of this expensive fertilizer, to consult the agricultural experiment station of his locality, or should determine the actual needs of his soil by experiments upon small plants. The quantity of Chile saltpetre which should be applied per acre varies with so many different conditions as to make any definite statement concerning it unreliable. On account of the great solubility of this salt no more should be used than is necessary for the temporary nutrition of the crop. For each 100 pounds of it used, from 14 to 15 pounds of oxidized nitrogen would be added to the soil. Field crops, as a rule, require less of the salt than garden crops. In the field crops there is an economic limit to the application of the salt which should not be passed. As a rule, 250 pounds per acre should be a maximum dresssing. The character of the crop must also be taken into consideration. Different amounts are required for sugar beets, tobacco, wheat and other standard crops. Cereal crops, especially, absorb a high percentage of the nitrogen in Chile saltpetre judiciously applied. As a rule, Chile saltpetre should be used as a temporary supply. Its presence diminishes to a certain extent the necessity for the activity of the nitrifying ferments, and its long continued use in sufficient quantities would evidently cause an enfeeblement of those organisms.

CONSUMPTION OF SODIUM NITRATE.

The entire consumption of Chile saltpetre for manurial purposes throughout the world at the present time is perhaps a little over a million tons annually, of a total value, delivered to a farmer, of over 40,000,000 dols. The approximate amounts annually consumed in different countries are as follows:

			Tons.
Germany	...	...	400,000
France	...	...	200,000
Belgium	...	...	125,000
England	...	...	120,000
United States	...	...	100,000
Holland	...	...	60,000
Italy and Spain	...	...	5,000
Other countries	...	...	6,000

VALUE OF CHILE SALTPETRE.

Chile saltpetre has a moderate value at the factories in Chile where it is prepared for shipment. Its high cost at the ports where it is de-

livered for consumption is due chiefly to the freights and the profits of the syndicate controlling the business.

The factories where it is prepared for the market are at or near the deposits, and the freights thence to the seacoast in Chile are very high. The railroads which have been constructed to the high plateaux which contain the deposits have been built at a very great cost, and the freights charged are correspondingly high. There is also a tax of 1·20 dol. levied by the Chilian government on each ton exported. Deducting all costs of transportation and export duties, the actual value of sodium nitrate at the factory ready for shipment is about 16 dols. in gold a ton.

METHOD OF PRESERVING NITRATES IN THE SOIL.

It is not possible at all times to maintain an equilibrium between the activity of the nitrifying organism and the needs of a growing crop. There are times when the amount of nitric acid produced is greater than the crop demands, while at other periods the needs of the crops may be far in excess of the ability of the organisms to supply. In the one case there will be a necessary increase in the amount of nitrates in the soil, while in the other the vigour of the growing crop will be at least temporarily checked. There are many practical points connected with this matter which must be of great interest to the farmer. As a rule, farming operations are carried on for profit and not for pleasure, and for this reason the more practical the results of scientific study the more useful they become to the great mass of agriculturists. The rich man who farms for pleasure can easily afford expenses in the way of fertilizers which the practical farmer must avoid. Happily, at those seasons of the year when crops grow less vigorously the activity of the nitrifying organisms is reduced to a minimum. For instance, the amount of nitric acid which is produced during tho winter is a very small quantity as compared with the production during the warm months. In the natural order of things, therefore, there is a tendency to conserve to the utmost the products of nitrification.

ABSORPTION OF NITRATES BY PLANTS.

Evidently the very best method of utilising the products of the activity of the soil ferments is to have them absorbed by a growing crop. For this reason, os well as for others of an economical nature, the farmer should have as little waste land as possible. Every acre which he possesses should either be devoted to forest, orchard, grass, pasturage, or cultivated crops. By thus occupying the land he will reduce to a minimum the losses which occur from the leaching of the soil by water.

It is well known that all agricultural crops store immense quantities of organic nitrogen in their tissues. As a rule the highest percentages of nitrogenous organic compounds are found in the seeds of plants, but it must not be forgotten that certain grasses which are harvested for hay also contain large quantities of nitrogen. This is especially true of clover. It is easily seen from the above how wasteful is the practice, now happily almost extinct, of burning the residue of cereal crops—as, far instance, Indian cornstalks and the straw of wheat—in order to prevent them from obstructing subsequent tillage. In this wasteful process it is true that the phosphoric acid and potash are saved and returned to the soil, but all the nitrogenous compounds are practically lost and dissipated in the air. The quantity of ammonia and

oxides of nitrogen which are produced in combustion is insignificant when compared with total nitrogenous content of the refuse matters mentioned above. It is far better that these residual matters be chopped as finely as possible and turned under by the plough. Although they may not decay with sufficient rapidity to be of much benefit to the next crop, yet they will gradually become decomposed and serve a most valuable end in contributing fresh stores of humus and nitrogen to the arable soil. Combustion is the most wasteful and also the least scientific method of disposing of the refuse of the field.

(To be continued.)

DIRECTIONS FOR CARE OF YOUNG GRAPE VINES. II.

By W. Cradwick, Superintendent of the Hope Gardens.

(Continued from June Bulletin, page 121.)

The young grape vines sent out from Hope Gardens last year should be pruned during the last week in February or the first week in March. This should be done by cutting the plant down to the strongest eye, which is generally the lowest and about 3 inches from the surface of the ground, as in figure 1.

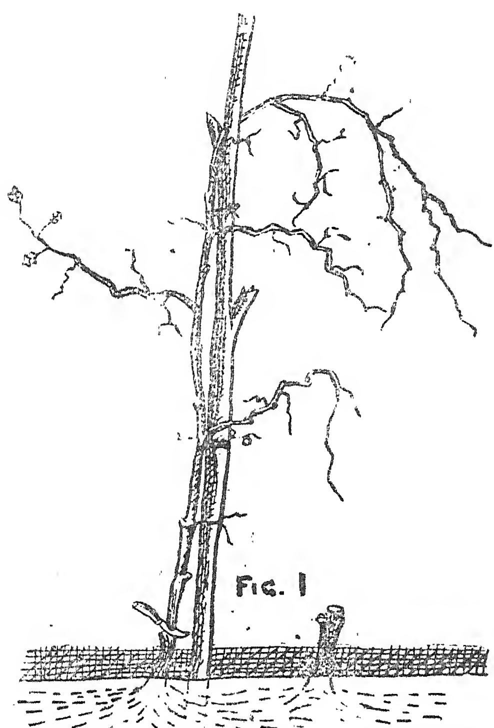

Fig. 1

When the grape vine commences to sprout again, only the strongest shoot must be allowed to grow to form the permanent vine; all small shoots must be cut off, see figure 2.

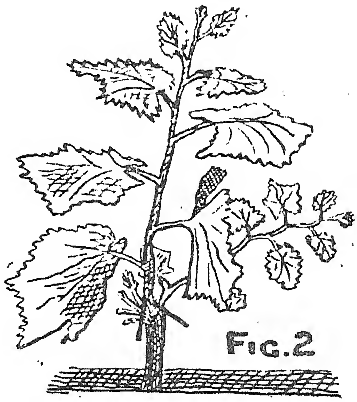

FIG. 2

This shoot must be kept trained straight or if the vine gets inconveniently long it should be very gradually turned as a sharp bend in a vine will check the flow of sap beyond the bend and over feed one part of the plant to the detriment of the other.

As the vine grows, it will send out side branches, which should have the points pinched out as soon as they have made two or three leaves as shewn in figure 3, and as they shoot out afresh, the points should

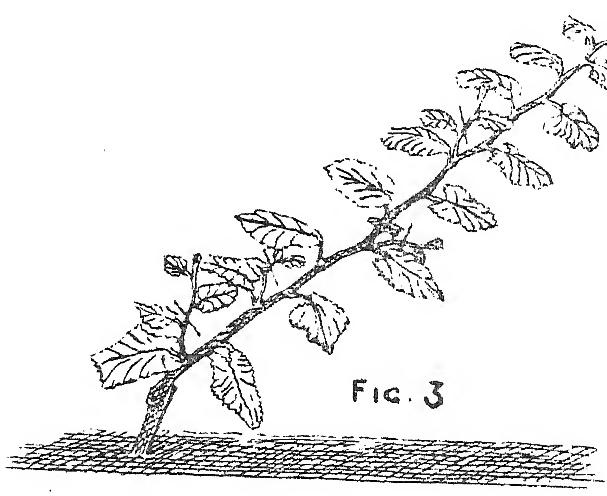

FIG. 3

be again removed. But on no account allow the point of the main growth to be touched or interfered with in any way. Try to make the vine grow as long as possible, it will get stout of its own accord. Cover the roots over with rotten cow manure or stable manure a foot thick if possible. Two weeks after pruning a thorough soaking of water must

be given, which should be repeated every fortnight up to the end of August, provided that it is not done naturally by rain.

The wood that is cut from the vine, when pruning, can be used for propagating young plants. To propagate the young plants, take the canes which have been cut off, select all the wood which is not thinner than one's little finger and cut this up into lengths, as shown in figure 4.

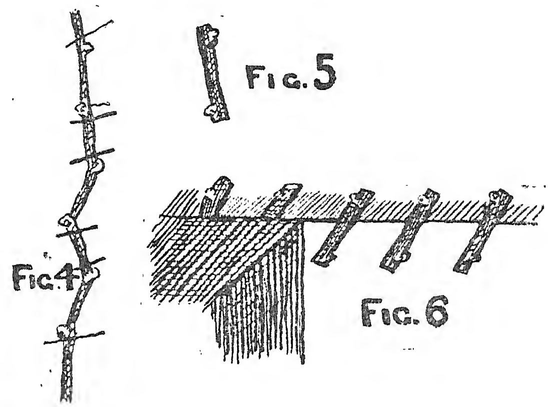

FIG. 4 FIG. 5 FIG. 6

This will give cuttings of two joints, as figure 5, but close to the buds and quite smoothly at both top and bottom of the cutting. Insert these, the right way up into a prepared bed, placing them three inches apart with two-thirds of their length under ground,—one eye will thus be under the ground and one above, as in figure 6

As soon as the cuttings have made a growth of four or five inches in length, they should be lifted and potted, or planted into their permauent positions and treated in the way advised for the young plants sent out from Hope Gardeus last year.

OUR INSECT PESTS.—

THEIR STRUCTURE AND LIFE HISTORY.*

By J. E Duerden, Curator of the Museum, Institute of Jamaica.

Perhaps one of the most marked faunal characteristics of the tropics is the predominance and peculiarities of its insect life. Whether during the day we remark the brightly coloured butterflies, the varied forms of the beetles, the wonderful activities of the ants and termites, the lace-winged dragon-flies, the strange stick and leaf insects; or, at dusk, the large and small moths which flutter round our lights, the shrill note of the crickets accompanying the evening song of other night-loving creatures, the flitting to and fro of the various fire-flies; or, still more, experience the tormenting mosquito, or on the trees in our gardens remark the prevalence of strange looking scales and large and gorgeously coloured caterpillars, do we realize the importance of the group here, compared with temperate parts. The constant dweller

* Report of a Popular Lecture, illustrated by lantern slides delivered in Spanish Town, November 23, 1896.

in the tropics, be he agriculturist or otherwise, has thus his attention continually directed towards the six-legged winged creatures, either in admiration of their form and beauty, or, perhaps more often, in execration at the petty annoyances to which they subject him and the more serious damage to agriculture resulting from their activities.

Seeing that insects have such a constant influence and importance in our daily lives we shall observe them with greater interest, may appreciate more their presence, or be better able to deal with them as pests, when we know somewhat of their organization and habits. Fortunately there is a general plan of structure applicable to insects, which is readily grasped, and which enables us easily to distinguish them from all other animals. Other characters again ally them to creatures appearing at first sight very distantly removed. Primarily we observe their bodies to be made up of distinct rings or segments. This ringed body they have in common with worms, centipedes, lobsters, scorpions, and spiders. Their paired legs are likewise seen to be constructed of several parts separated by joints, differing in form and purpose according to the position in the body of the part we select. In this they differ entirely from the segmented worms, which have only hairs or bristles to aid them in locomotion, but agree with the remaining groups mentioned. This common character of the appendages enables us to form a great group of the animal kingdom, the *Arthropoda*, or jointed-footed animals. By the number of these feet we can also separate the insects from most of the other members of the Arthropoda. The centipedes, lobsters, etc., have a pair, of one shape or another, to every ring; scorpions and spiders have four pairs restricted to the front segments, but insects are all limited to three pairs of true walking legs in the middle division of their body. Again, lobsters and spiders have the whole body divisible into two main portions; insects have, with few exceptions, three distinct and separate regions—the *head*, *thorax*, and *abdomen*. Finally, insects differ most advantageously from all other arthropods in the possession of wings; usually two pairs fixed to the two last rings of the thorax. These are to be regarded as outgrowths from the body; perhaps, with their hollow veins, developed primarily for respiratory purposes, but afterwards taking on the very important function of aerial locomotion.

By their means insects alone, among the invertebrates, occupy an exalted and active position in the air, such as is occupied by the birds among the vertebrates. To the gift of wings must be attributed the wonderful numerical success of insects in the struggle for existence, as well as that of birds; and, in a measure, their advance in activity and intelligence. To sum up, insects are distinguished from all other animals by the following combination of characters: The division of the body into three regions, head, thorax, and abdomen, the two first being separated by a well defined neck; the possession of one pair of feelers or antennæ on the head; the thorax with only three segments, each bearing a pair of jointed legs, and usually a pair of wings to the two last rings; and, lastly, the abdomen with nine or ten segments.

The paired eyes on the head are generally fixed and differ much in plan from the eyes of higher animals, each being a combination somewhat equivalent to very numerous single eyes. Experiments seem to point to the conclusion that insects cannot distinguish by their eyes

the forms of objects, or at best, very poorly. The antennæ or feelers have important functions, probably connected with motion, touch, hearing, taste, or smell.

The external covering of all insects, and indeed of all the *Articulata* or segmented animals, is a substance, usually more or less hardened, known as chitin. It is an excretion from the soft underlying cellular layer, the epidermis. In the burrowing earthworms a protective covering is not much required, and the cuticle is very thin and delicate. In crabs and lobsters it becomes impregnated with lime salts, and consequently very hard and a most effectual protection. This would, however, be too heavy for the air-disporting insects. It is to be noticed that the chitinous case is not stiffened at the joints, so that movement of one part of the body upon another is allowed. The outer skin becoming hard and inelastic soon after exposure, the necessity for the creatures, while increasing in size, to be occasionally moulting their skin as a whole is obvious.

The internal structure of insects can best be studied on such a form as our common large cockroach. Although a very objectionable and much despised creature the cockroach is worthy of our great respect on account of its long ancestry. We occasionally give honour to individuals who can boast only of this as their recommendation, and it is certainly one redeeming feature in the present case. Forms similar to the cockroach are met with amongst the early fossiliferous rocks, and extend, unquestionably without any signs of extinction, down to the present day.

On pinning down a cockroach and cutting away the upper portion of the body-wall the interior is seen almost filled with a white loose substance, which is mainly fatty matter held together by the fine air-tubes or tracheæ. When this is cleared away a partially coiled tube is seen extending the whole length of the body. It is the food-canal of the animal and is divisible into different parts, each with a separate function in the complex process of digestion. Outgrowths from it occur at different places; two in front are known as salivary glands and produce a digestive fluid, and two other groups occur behind. The first, consisting of short pouch-like tubes, secretes another digestive fluid, and the second group of long slender tubes has an excretory function. The dorsal heart and the blood vessels are not readily seen. Running all the length of the ventral surface of the body-cavity, which is not however a true *cœlome*, is the double nerve-cord, with enlargments corresponding somewhat with each segment and from which are given off fine branches to all parts of the body. The complex reproductive organs are seen behind.

With some interesting exceptions, all insects develop from eggs. The life of most may be divided into three stages: the *larva*, caterpillar, or grub; the *pupa* or *chrysalis*; and the *imago* or adult; the change from one to the other being spoken of as a *metamorphosis*. The differences between the various stages are however very diverse in the many groups; the obvious alterations being much more marked in some than in others. Illustrative examples were given from slides showing the life-history of the silk worm, *Bombyx;* the Water-beetle, *Dytiscus*; and the Hawk-moths, *Sphingidæ*.

THE HAWK-MOTHS.

The Hawk-moths are among the large moths which, in the evenings, often fly into rooms. They are stout, strong insects, with large hairy bodies. The sucking tube or tongue is extended to a great length, so that it may reach the sweet fluids at the bottom of flowers with a long tubular coralla.

The caterpillars of the various species are large, stout, and smooth, with very beautiful and striking colours. They are continually brought into the Museum as remarkable objects. Those belonging to the family may usually be readily distinguished by the possession of a hump or horn on the eighth abdominal segment. The pupæ are occasionally met with in digging the ground. They are spindle-shaped, often with a long jug-like handle, which is really the case of the sucking tube. The green caterpillar with oblique white lateral lines and a curved hook towards the end of the body, and which lives mostly on the leaves of the tomato, is a well known form.

PLAGUE OF CATERPILLARS.

Not far removed from the Hawk-moths are the insects which have lately given rise in Jamaica to a plague of caterpillars.

A few weeks ago accounts appeared in the papers that the guinea-grass covering extensive areas in different districts of the southern portion of the island, and also around Kingston, was being destroyed by caterpillars. Specimens of these were sent to the Museum and were allowed to pupate and afterwards the moth was hatched. They are closely allied to the well known "army-worm" of America. The long slender caterpillar lives mainly upon grass, but attacks also corn and sugar-cane. It eats away practically all the young leaves, only the dead stalks remaining In such numbers do they occur that a whole district may be quickly devastated. The pupal stage in similar forms elsewhere is passed through in the ground, but in the Jamaican species the caterpillar makes for itself a kind of chamber by joining portions of the leaves of grass and forming a thin lining by means of fine threads. In this the small, brown, spindle-shaped pupa passes through its metamorphosis, the result being a medium-sized moth. No further accounts have been received from the country for two or three weeks, so that very probably our worst times are over. The excessive development, at times, of different forms of caterpillars, as compared with other times, is mostly dependent upon peculiarities in climatic conditions.

Since this was first written I have heard from one of my correspondents that the caterpillars which had disappeared seem to be now returning in as great numbers, and are again destroying the grass. No doubt these are derived from the batch of eggs laid by the moths resulting from the first caterpillars, and there seems no reason why we should not look forward to a regular sequence of such visitations.

SCALE INSECTS.

The scale insects or bark-lice are well known to every observer in the tropics, and to those concerned in conservatories elsewhere with plants from warmer parts. In many respects they form a very peculiar group, and a wonderful variety of species exists within the family, *Coccidæ*, as it is termed. In appearance and habits they differ greatly

from other insects, and even the two sexes of the same species are much unlike. The females pass the greater part of their life entirely motionless on trees and shrubs; nothing in their exterior would lead one to suppose them insects. When mature and ready for laying eggs the scale appears rather as an excrescence of the tree. The males at one stage are lively and active, but have then only a single pair of wings, and no organs for procuring food. The mouth parts disappear during the metamorphosis of the insect, and a second pair of eyes appears in their place. The female is always sluggish and wingless, and in the adult the body is generally scale- or gall-like, or grub-like and clothed with wax. Though the body of the larval female is ringed and bears legs, all trace of segmentation is usually lost later. Among the *Coccidæ* are found many of the most serious pests of the horticulturist and agriculturist; scarcely any kind of fruit tree is free from their attacks. The numerous species described from Jamaica by one of the former Curators of the Museum, who made a speciality of this group, is evidence of their great abundance in this island, whilst almost daily specimens are still sent to the Museum for examination. During recent years much attention has been paid, more especially in America, to devising methods for destroying and checking the pests; the insecticides which are now most widely used being alkaline washes and kerosene emulsions.

Perhaps the scale of greatest concern at present to us in Jamaica is the Mussel-scale, *Mytilaspis citricola,* affecting the oranges; more particularly in the lower, drier parts of the island. It is not rare around Kingston, and I have received oranges affected with it from St. Ann; but, in the higher orange growing districts of the island, as at Mandeville, it does not appear to be very prevalent. In its structure and life-history it exhibits some most remarkable conditions and may be taken as representative of the group.

The scale in the stage we are most familiar with is a minute brown mussel-shaped body, about one-eighth of an inch long, flattened on its adhering surface, but convex on the other; a slight margin of lighter, less dense material is present. If turned over and examined with a lens it is seen to be either a dead hollow chamber with a partial, membranous floor, or else to contain small eggs irregularly arranged The manner in which this condition is brought about is one of the most striking processes in insect life. For what follows we are indebted mainly to the researches of the American entomologists. Starting with the eggs laid by the mother we find that they undergo development, producing minute creatures, mere specks, scarcely distinguishable to the untrained eye. The newly hatched scale insect is oval in outline, much flattened, furnished with six legs, a pair of antennæ, and an apparatus for sucking the juice from plants. After wandering about for a time, usually a few hours or even less, the young insect settles on some part of a plant, inserts its beak, and drawing nourishment from the tissues, commences its growth at the expense of its host. In a short time there begins to exude from the body of the larva fine threads of wax, which are cottony in appearance. Sooner or later the larva begins to excrete a pellicle, which, although very thin, is dense and firm in texture. The mass of cottony fibres either melts or is blown away. After a period the larva sheds its

skin; in some species after the permanent scale begins to form, in others before. In this latter case the larval scale is plainly visible, either upon the surface of the scale, or at one extremity, as in *Mytilaspis*. The change which the larva undergoes in this first moult is a very remarkable one; with the skin are shed the legs and the antennæ, and the young scale insect thus becomes a degraded grub-like creature, with no organs of locomotion. The mouth parts remain and by them the insect is firmly attached to the plant and continues to draw its nourishment from it. From this stage the development of the two sexes differs.

In the second and last moult of the female the second skin is joined to the first and with it forms part of the scale which covers the body of the insect, but generally it constitutes only a small proportion of the ultimate scale, the greater part of which is excreted subsequently to the second moult.

Soon after the second moult of the females, the adult males emerge and impregnation is supposed to occur at once. The body of the female then increases in size, becoming distended with eggs; these are deposited beneath the scale, the body of the mother gradually shrinking to make room for them. Ultimately the parent dies, but the eggs continue their development; the dead body of the mother, with its scale, serving as a chamber or cradle for their protection until hatched. The male scale insect during the early part of its grub-life is indistinguishable from the female. At the first moult, like the female, it loses its legs and antennæ; the second moult agrees with that of the female, but there the similarity in form between the two sexes ceases. It is now in the pupa state, and has long antennæ, and rudimentary legs and wings. After a third casting of the skin the adult male appears with three pairs of legs, and a large pair of wings in front, by means of which it can fly, but the mouth parts are replaced by supplementary eyes, and it is unable to eat. In the particular genus, *Mytilaspis,* to which the orange scale belongs, the scale proper of the female is elongated, and the exuviæ or dead skins are seen at one extremity. The scale of the male is similar in form to that of the female, only smaller. Fortunately it does not appear that the scales injure the trees or the oranges very seriously in Jamaica, but the unsightly appearance given to the fruit when the parasite adheres in considerable numbers, renders it desirable that measures should be taken to prevent the spread of the pest.

A WAX-PRODUCING SCALE.

In one group of scale insects forming the genus *Ceroplastes*, the body in the adult condition is furnished with a thick covering of waxy material, produeed as an excrescence of the animal. It does not, however, adhere very closely to the insect. Quite recently an example has been contributed to the Museum by Mr. Campbell, of the Parade Gardens, which infests some of the trees in considerable numbers. Mr. Cockerell, to whom it has been forwarded, has described it as a new species, *Ceroplastes confluens,* and notes that it may be well to obtain all possible information respecting it, suggesting that the wax may be of economic importance.

THE LOTUS OF THE NEW WORLD.

NELUMBIUM LUTEUM, WILLD.

At Hope Gardens there is now flowering a very remarkable and beautiful water lily—the Lotus of the New World.

It is a native of Jamaica and the United States, the only other species of this genius (*Nelumbium speciosum*) the Sacred Lotus, being a native of the tropics of the Old World.

Both species agree in the peculiar seed vessel, which was compared by Herodotus to a wasp's nest. It is formed by the ovary becoming very much enlarged after the fall of the petals; it is funnel-shaped but solid. In the flat top of this receptacle there are numerous cavities sunk, in each of which is a large bean or seed. The seeds are loose and rattle in their holes, but cannot fall out as the top of the cavity is smaller than the seed itself.

The colour of the flower of the native species is a light yellow, that of the Sacred Lotus being rose or white.

The leaves are somewhat saucer-shaped, with the stock coming from the centre below, and do not float on the water but are carried up above the surface. The Hindoos have a proverb to the effect that "the good and virtuous man is not enslaved by passion or polluted by vice; for though he may be immersed in the waters of temptation, yet like a lotus leaf he will rise uninjured by them." The spiral fibres found in the leaf stalks are used as wicks in the temples of India to burn before the images of the gods. The leaves themselves are employed as plates on which sacred offerings are placed.

The Sacred Lotus also obtained a place in the religious ceremonies of the ancient Egyptians. "Sculptured representations of it abound among the ruins of the temples, and many other circumstances prove the veneration paid to this plant by the votaries of Isis."

The root-stocks and seeds of both species have been used as food, and various parts medicinally.

Dr. Patrick Browne in his "Civil and Natural History of Jamaica," published in A. D. 1756, says, "this plant is pretty common in the lagoons beyond the Ferry; but I have not observed it in any of the deeper waters. It seems to grow best in a loose, boggy ground, where the leaves may stand in open air, while the roots, and lower part of the stem are plentifully supplied with moisture."

It does not seem to have been found by later botanists until the year 1847. Swartz, Bertero, McNab, Purdie and Macfadyen frequently visited the locality mentioned by Browne but failed to come across it. Dr. Macfadyen however had it brought to him, as he states in a pamphlet printed (but not published) in 1847, "early in August, James Dundas, Esq., (the manager of Taylor's Caymanas Estate) in carrying out some improvements connected with the draining of the land of that property in the vicinity of the lagoon, unexpectedly came upon this beautiful plant, and as he had on former occasions assisted in the kindest manner our searches for the plant he immediately concluded that he had at length alighted on what he had been so long in search of. He collected the specimens of the flowers and other parts of the plant, and brought them to my residence in Kingston. I doubt not every cultivator of our

'fair science' must sympathise in the pleasure with which I regarded this beautiful plant. How much more delightful would be the surprise to encounter it in its native solitudes, where the hand of Nature has planted and reared it, amid the mangroves and the tall reeds, overshadowing with its magnificent leaves and flowers the still waters of the lagoon, recalling the description of Una in the Fairy Queen.

'Her angel face
As the great eye of heaven shined bright
And made a sunshine in the shady place.'"

The present Director having seen it growing in all its beauty on an island in the Mississippi in a wide stretch, 100 yards long by 50 broad, made attempts but without success to trace it again 8 or 9 years ago in the neighbourhood of Caymanas estate, the only spot from which it had been recorded. It was therefore with great pleasure that a seed-vessel was received in 1890 from Mr. R. K. Tomlinson, who had found it in swamps in St. Elizabeth.

It is only lately that it has been possible to provide a place for it at Hope Gardens; where it is now flowering. Mr. Jenman, Superintendent of the Botanic Gardens in British Guiana, writes as follows :—

"Of the *Nelumbium luteum* seed you sent me in July, 1895, one plant survived. After three or four months' growth in a pot, in a tub of water, it was planted out in a bay of one of the lakes. It now covers from three to four hundred square yards surface, and is flowering as freely as N. speciosum, whose stems form dense thickets in the trenches and lakes here. I think I told you before that I have had the Florida plant here for the past ten or eleven years, and though it has covered a great area, it is not at all rampant as the Jamaica one has proved itself, and has never flowered. The only explanation is that the latter is adapted to the climate here and the other is not."

Mr. Jenman's statement is remarkable, and it is is interesting to compare with it the first record of its flowering in England, given in the "Botanical Magazine" by Mr. Sylvester :—Its flowering, I believe, to have been the consequence of an accidental circumstance, which I shall mention. I had hitherto treated it like the Red or eastern species. from an impression that it was confined to the most southern and warmest portion of North America ; the pots of both being plunged in a cistern of water, kept at a heat of about 86 degrees and as the plants grew very vigorously and appeared to be in health, I did not try any other situation. They had never shown any disposition to bloom until the present season, when in consequence of the gardener having left a smaller opeuing than usual in the flue that passes under the cistern, and which is entirely closed in the winter, the water remained at about 70 or 75 degrees, and the house was altogether cooler than in previous summers. Under these circumstances, while the Red species threw up a number of flower buds, none of which came to maturity, two out of the three plants of the yellow-blossomed sort flowered and are ripening seeds. The house and the water have since been warmer, and *N. speciosum* is now, though later in the season, coming into bloom.

FERNS: SYNOPTICAL LIST—XLII.

Synoptical List, with descriptions, of the Ferns and Fern-Allies of Jamaica. By G. S. JENMAN, *Superintendent Botanical Garden, Demerara.*

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5. *Nephrolepis biserrata*, Schott.—Stipites strong, erect, tufted, 6-10 in. l. polished, slightly fibrillose or furfuraceous; fronds 2-4 ft. l. 6-10 in. w., narrowed at the base; chartaceous or membranous, bright; often pale, green; naked puberulous or slightly pubescent when young; pinnæ numerous, spreading horizontally, linear-lanceolate and acuminate, approximate or subdistant, 4-6 in. l. $\frac{1}{2}$-$\frac{3}{4}$ in. w., base substipitate, truncate or rather rounded or the inferior subcordate, slghtly disposed to be auricled on both sides; margins variable, even, serrulate or bicrenate-serrulate, rachis strong, glossy, channelled, deciduously furfuraceous; veins twice forked; midrib strong, channelled; sori intramarginal punctiform, sporangia yellowish when ripe; involucres small, naked or ciliate, ultimately cordate-orbicular. Pl. Fil. t. 112. *N. acuta*, Presl. and several other names. Aspidium punctulaum, Swartz.

Plentiful among bushes and on banks and trees among the lower hills. A much larger plant than the preceding, of erect spreading or pendent habit, growing more or less in masses. It varies much in size and in the vestiture of the surface. There is a pubescent form with pinnæ only 4-5 l. w., more deeply and uniformly serrulate, and often furcate, the sori submarginal. The upper surface is papillose over the sori.

GENUS XXVIII. OLEANDRA, CAV.

Sori round, dot-like, scattered, or in irregular transverse lines, on the back of the veins, more plentifully toward the costæ; involucres superior cordate-orbicular, attached by the sinus, free around the edge fronds entire, naked or ciliate, with a satiny gloss; stipites articulated veins free, spreading at a wide angle; root-stock long-repent.

This genus, like the preceding, depends upon the homology and distinct habit, and the common physiognomy of its members, in the absence of any distinguishing characters of fructification, to give it generic recognition. It contains a score or so of species or varieties which inhabit rocks, prostrate trunks of decaying trees, the crowns of palms and similar situations, and are scattered over the tropical and warm regions of the world, reaching southward to Australia.

O. nodosa, Presl.—Rootstock repent, prostrate extending often several feet long; firm, cylindrical, not so thick as a quill, branched, clothed with copious silky fine squarrose ferruginous scales; stipites distant, slender polished, dark-coloured, 4-6 in. l., the raised articulate joint $\frac{1}{4}$-2 in. from the base; fronds oblong lanceolate, acuminate or cuspidate, the point fine, 10-18 in. l. $1\frac{1}{2}$-3 in. w. the base tapering or cuneate; margins often repand, entire; cartilaginous-edged, chartaceous, pellucid; or bright-satiny green, naked or with a few deciduous scattered minute scales along the costæ beneath; veins fine, very close, simple or once forked from near the base, nearly horizontal; sori copious, scattered but most crowded near the dark, coloured, glossy costæ, which is channelled down the face; involucres dark-brown, naked.—Pl. Fil. t. 136. *Aspidium*, Willd.

Very common in shady and open places in coffee plantations and forests trailing over rocks and decaying logs from 1,000-3,000 or 4,000 ft. alt. The fronds part at the articulation, and drop, leaving the base of the stipe adherent to the rootstock. In this the rootstock is horizontal in growth, while in the other American species, *O. neriiformis*, Cav. it is erect with the joint of the petioles at the base, and with smooth or hairy surfaces.

Genus XXIX. Fadyenia, Hook.

Fronds acaulose, entire, dimorphous, veins areolated; receptacles oblong, on free included veinlets; sori large, deeper than broad, oblong-reniform, with a deep sinus and converging auricles; involucres ample, attached interiorly, the exterior edge free.

A monotypic genus, found only in Jamaica and Cuba. The sori are several times larger than in any other genus of the Tribe, being 1½-2 l. l. by 1½ l. w., doubled in the form of a horse shoe, on an elongated receptacle, the folded ends converging almost together at the base. Occasionally the veinlet extends beyong the sorus to the other side of the mesh.

F. prolifera, Hook.—Rootstock small, fibrous-rooted, fronds simple, entire, cæspitose with hardly any distinct stipites, fibrillose at the tapering base; barren prostrate, narrowed both ways from the centre, outwards into a much elongated tapering tail proliferous and rooting at the summit. ¾-1 in. w., 3-7 in. l.; fertile erect, oblanceolate, rounded at the summit, narrowed in the sterile lower half to the long-tapering base, 4-6 in. l. 4-5 li. w.; both fronds naked, dark-green; membrano-chartaceous; costal areola large, exterior smaller with free branches along the margins; sori unserial between the midrib and edge, usually confined to the costal meshes; involucres persistent, at length shrivelling. Sl. t. 25. f. 1. Hook. & Grev. Ic. t. 96. Hook. Jen. t. 53. B. Hook. Fil. Exot. t. 36. *Asplenium*, Sw. *Aspidium*, Mett.

Infrequent on the wet banks in the eastern parishes up to 2,000 ft. altitude. In the barren fronds it resembles *Aspidium rhiozphyllum*. The earlier fronds are oblanceolated; the next rather ovate-lanceolate, extending into a much-elongated winged tail a line or less wide at the radicant summit. In the fertile this is reversed; they taper similarly, but inwards to the base, and only the broader outer part is fertile. Occasionally an odd reduced sorus is produced in one of the smaller outer meshes. Most of the space between the midrib and margin is taken up by the sori, which run more or less parallel therewith.

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Plants.

From Royal Gardens, Kew.—

Tubers of Tampico Jalap (Ipomæa simulans) from Tlacolulam, from Tonayan, and Vera Cruz.

Seeds.

From Royal Gardens Kew.

Iris Robinsoniana
Cornus asperifolia
Persea indica
Pyrus irregularis
Aesculus arguta
Pritchardia Thurstoni
Copernicia cerifera
Perak Lemon
Apocynum venetum

From Messrs. Reasoner, Bros. Florida.
Chamæops humilis, var. farinosa
" " " hystrix
" " " spinosa
" " " littoralis
Phœnix paludosa
" sylvestris
Sabal Palmetto
Ilex ambigua
Raphiolepis ovata
Myrica cerifera
Viburnum obovatum

From Botanic Gardens, Bangalore.
Moringa pterygosperma

From Agri.-Hort., Society, Madras.
Acacia Sundra
Adenanthera pavonina
Azadirachta indica
Bombax malabaricum
Cassia Fistula
" nodosa
Cæsalpinia Sappan
Erythrina indica
Ficus indica
" racemosa
" religiosa
Gmelina arborea
Hibiscus collinus
Lagerstroemia Flos-reginæ
Parkia biglandulosa
Pterocarpus Marsupium
Peltophorum ferrugineum
Sterculia foetida
Thespesia populnea
Terminalia sp.

From Walter Jekyll Esq., Robertsfield.
Alstrœmeria chilensis

From Secretary Colonia Cosme, Paraguay
Tembo
Curupay Naj
Ybiripita
Mandioca

From Lt. Col. the Hon. C. J. Ward, C.M.G.
Fruits of Citron

From Botanical Station British Honduras.
Dombeya molle
Ipomæa sp.
Malvacea

From Messrs Dammann, & Co., Italy
Iris germanica
" florentina
" pallida

From Royal Botanic Gardens, Trinidad.
Trinidad Lime
Lignum Vitæ

CASTLETON GARDENS.

January.

In Flower.

Acacia cyanophylla, Lindl.
(Blue-leaved Acacia : Australia.)
Amherstia nobilis, Wall.
(Amherstia : India and Malaca.)
Bauhinia variegata, Linn.
(Butterfly tree : India and China)
Broughtonia lilacina, Henfr.
(Jamaica, Cuba and Hayti)
Broughtonia sanguinea, R. Br.
(Jamaica, Cuba)
Cananga odorata, Hook. f. & Thoms.
(Cananga, Ilang : India)
Cassia glauca, Lam.
(Glaucous Cassia, Trop. Asia, Australia, and Polynesia
Cinnamomum zeylanicum, Nees.
(Cinnamon : Ceylon)
Cocos botryophora, Mart.
(A Brazilian Palm)
Coffea liberica, Hiern.
(Liberian Coffee : W. Africa)
Cynometra americana, Vog.
(S. Domingo)
Erythrina umbrosa, H. B. & K.
(Bois Immortelle : S. America)
Fagræa obovata, Wall.
(E. Indies)
Hibiscus elatus, Sw.
(Blue Mahoe : W. Indies)
Hyophorbe Verschaffeltii, Wendl.
(Palm from Mauritius)
Jacaranda filicifolia, D. Don.
(Fern-leaved Jacaranda : Guiana)
Musa coccinea, Andr.
(A bright or red-flowering banana : S. China)
Musa rosacea, Jacq.
(A reddish-lilac flowering banana, E. Himalayas)
Napoleona imperialis, Beauv.
(Napoleona : W. Africa)
Norantea Guianensis, Aubl.
(Norantea : Guiana and Brazil)
Phaius grandifolius, Lour.
(Nun Orchid)
Phœnix acaulis, Buch.—Ham.
(Stemless Palm : Central India)
Rhodoleia Championi, Hook.
(Small tree from Hong Kong)
Tectona grandis, Linn. f.
(Teak : India.)

In Fruit.

Artocarpus Lacoocha, Roxb.
(Indian Breadfruit : India and Malaya)
Attalea Cohune, Mart.
(Cohune Palm : Honduras to Guiana)
Averrhoa carambola, Linn.
(Carambola : E. Indies)
Barringtonia Butonica, Forst.
(Barringtonia : E. Indies)
Caryocar nuciferum, Linn.
(Souari or Butter Nut : Guiana)
Coffea liberica, Hiern.
(Liberian Coffee : W. Africa)
Couroupita guianensis, Aubl.
(Cannon Ball Tree : Trop. Amer.)
Dillenia indica, Linn.
(Dillenia : E. Indies)
Diospyros discolor, Willd.
(Mabola Ebony : Philippines)
Dypsis madagascariensis, Hort.
(A Palm : Madagascar)
Garcinia Mangostana, Linn.
(Mangosteen : Malay Archipelago)
Lonchocarpus cyanescens, Benth.
(Yoruba Indigo : W. trop. Africa)
Manihot Glaziovii, Muell. Arg.
(Ceara Rubber : Brazil)
Myristica fragrans, Houtt.
(Nutmeg : E. Indies)
Noronhia emarginata, Thou.
(A Madagascar tree)
Oreodoxa regia, H. B. & K.
(Royal Palm : Cuba)
Pachira aquatica, Aubl.
(Pachira : Panama)
Pandanus utilis, Bory.
(Screw Pine : Madagascar)
Semecarpus Anacardium, Linn.
(Marking Nut Tree : India)

FEBRUARY.

IN FLOWER.	IN FRUIT.
Amherstia nobilis, Wall, (Amherstia : India and Malacca) Arenga saccharifera, Labill. (Sugar Palm : Burma and Malay Archipalago) Aspasia variegata, Lindl. (A tropical S. American Orchid) Bignonia magnifica, Bull. (Colombian Bignonia: Colombia) Cocos botryophora, Mart. (A Brazilian Palm) Cœlogyne ovalis, Lindl. (A Himalayan Orchid) Calliandra falcata, Benth. (Cent. Amer.) Cananga odorata, Hook. f. & Thoms (Cananga, Ilang : India). Carludovica gracilis, Liebm. (Ippi-appi : W. Indies) Chrysobalanus Icaco, L. (Coco-plum : West Indies) Cinnamomum zeylanicum, Nees. (Cinnamon : Ceylon) Coffea liberica, Hiern. (Liberian Coffea : W. Africa) Cola acuminata, Schot. & Endl. (Kola nut : W. tropical Africa) Dictyosperma album, H. Wendl. & Drude (Piassava Palm : Madagascar) Elettaria Cardamomum, Maton (Cardamon : India) Erythrina umbrosa, H. B. & K. (Bois Immortelle : S. America) Erythroxylon Coca, Lam. (Coca : Andes) Eugenia caryophyllata, Thunb. (Clove : Moluccas) Faradaya splendida, F. Muell. (An Australian Climber) Garcinia indica, Choisy. (Kokam Butter : India) Hibiscus elatus, Sw. (Blue Mahoe : W. Indies) Jacaranda filicifolia, D. Don (Fern-leaved Jacaranda : Guiana) Landolphia florida, Benth. (Rubber Vine : W. Africa) Latania Verschaffeltii, Linn. (A Palm from Rodriguez Island) Lonchocarpus violaceus, H. B. & K. (A tropical American tree) Mesus ferrea, Linn. (Naghas Tree : India) Michelia Champaca, Linn. (Champac tree : India) Musa textilis, Nee. (Manilla hemp : Phillippines)	Araucaria Bidwillii, Hook. (Bunya-Bunya Pine : Queensland) Areca Catechu, Linn. (Betel Nut Palm : Malaya) Attalea Cohune, Mart. (Cohune Palm : Honduras to Guiana) Barringtonia Butonica, Forst. (Barringtonia : E. Indies) Bauhinia variegata, Linn. (Butterfly tree : India and China) Bignonia magnifica, Bull (Colombian Bignonia : Colombia) Caryota urens, Linn. (Wine Palm : India and Ceylon) Chrysalidocarpus lutescens, Wendl. (A Mauritius Palm) Cocos flexuosa, Mart. (A Brazilian Palm) Coffea liberica, Hiern. (Liberian Coffee : W. Africa) Colvillea racemosa, Boj. (A Madagascar tree) Dictyosperma album, H. Wendl. and Drude (Piassava Palm : Madagascar) Dillenia indica, Linn. (Dillenia : E. Indies) Diospyros discolor, Willd. (Mabola Ebony : Philippines) Diplothemium caudescens, Mart. (A Brazilian Palm) Dipteryx odorata, Willd. (Tonquin Bean : Cayenne) Elettaria Cardamomum, Maton. (Cardamom : India) Entada scandens, Benth. (Cacoon : Tropics) Erythrina umbrosa, H. B. & K. (Bois Immortelle : S. America) Eugenia caryophyllata, Thunb. (Clove : Molluccas) Garcinia Mangostana, Linn. (Mangosteen : Malay Archipelago) Garcinia Morella, Desrouss. (Gamboge tree : E. Indies.) Hibiscus elatus, Sw. (Blue Mahoe : W. Indies) Livistona australis (A Palm : Australia) Livistona chinensis, R. Br. (Fan Palm : China, Japan) Lonchocarpus cyanescens, Benth. (Yoruba Indigo : W. Trop. Africa.) Manihot Glaziovii, Muell. Arg. (Ceara Rubber : Brazil) Mimusops Elengi, Linn. (Elengi : E. Indies)

FEBRUARY, *contd.*

IN FLOWER.

Napoleona imperialis, Beauv.
(Napoleona : W. Africa)
Nephelium Lit-chi, Camb.
(Litchi tree : S. China)
Pachira aquatica, Aubl.
(Pachira : Panama)
Phaius grandifolius, Lour.
(Nun Orchid)
Pterospermum acerifolium, Willd.
(Maple-leaved Pterospermum : India)
Quassia amara, Linn.
(Quassia : Surinam)
Rhodoleia Championi, Hook.
(Small tree from Hong Kong)
Saraca indica, Linn.
(Ushoka : E. Indies)
Spathodea campanulata, Beauv.
(Spathodea : Tropical Africa)
Sterculia carthaginensis, Cav.
("Chica" : Trop. Amer. & Brazil)
Strychnos Nux-vomica, Linn.
(Nux-vomica : E. Indies)
Tectona grandis, Linn. f.
(Teak : India)

IN FLOWER.

Musa textilis, Nee
(Manilla Hemp : Philippines)
Myristica fragrans, Houtt.
(Nutmeg : E. Indies)
Oredoxa regia, H. B. & K.
(Royal Palm : Cuba)
Pachira aquatica, Aubl.
(Pachira : Panama)
Pachyrhizus tuberosus, Spreng.
(Yam Bean : Trop. Asia)
Pandanus utillis, Bory
(Screw Pine : Madagascar)
Pithecolobium dulce, Benth.
(Guamuchil : Cent. Amer.)
Sapindus Saponaria, Linn.
(Soap-berry : W. Indies and trop. Amer.)
Sapindus inæqualis
(Soap-berry : W. Indies and trop. Amer.)
Sarcocephalus esculentus, Afzel.
(Sierra Leone Peach : Upper Guinea
Semecarpus Anacardium, Linn, f.
(Marking Nut Tree : India)
Strychnos Nux-vomica, Linn.
(Nux-Vomica : E. Indies)
Terminalia Arjuna, Bedd.
(Arjun tree : India and Ceylon)

MARCH.

IN FLOWER.

Acacia cyanophylla, Lindl.
(Blue-leaved Acacia : Australia)
Archontophœnix Cunninghamii, H. Wendl. & Drude
(Cunningham's Palm : Australia)
Artocarpus Lakoocha, Roxb.
(Indian Breadfruit : India and Malaya)
Aspasia variegata, Lindl.
(A tropical S. American Orchid)
Bignonia magnifica, Bull
(Colombian Bignonia : Colombia)
Brownea Rosa-de-monte, Berg.
(Rosa-de-Monte : Trop. S. America)
Cananga odorata, Hook. f. & Thoms.
(Cananga, Ilang : India)
Carludovica gracilis, Liebm.
(Ippi-appi : W. Indies)
Cinnamomum Camphora, T. Nees & Eberm.
(Camphor Laurel : China and Japan)

IN FRUIT.

Areca Catechu, Linn.
(Betel Nut Palm : Malaya)
Archontophœnix Cunninghamii, H. Wendl. & Drude
(Cunningham's Palm : Australia)
Araucaria Bidwillii, Hook.
(Bunya-bunya Pine : Queensland)
Barringtonia Butonica, Forst.
(Barringtonia : E. Indies)
Bignonia magnifica, Bull
(Colombian Bignonia : Colombia)
Cananga odorata, Hook. f. & Thoms.
(Cananga, Ilang : India)
Cocos flexuosa, Mart.
(A Brazillian Palm)
Coffea liberica, Hiern.
(Liberian Coffee : W. Africa)
Caryota urens, Linn.
(Wine Palm : E. Indies)
Chrysalidocarpus lutescens, Wendl.
(A Mauritius Palm]
Colvillea racemosa, Boj.
(A Madagascar tree)

IN FLOWER.	IN FRUIT.
Cinnamomum zeylanicum, Nees (Cinnamon : Ceylon)	Chrysobalanus Icaco, L. (Coco-Plum : W. Indies)
Cocos australis, Mart. (A S. Brazilian Palm)	Dictyosperma album, H. Wendl & Drude (Piassava Palm : Madagascar)
Coffea liberica, Hiern (Liberian Coffee : W. Africa)	Dillenia indica, Linn. (Dillenia : E. Indies)
Dictyosperma album. H. Wendl, & Drude (Piassava Palm : Madagascar)	Diospyros discolor, Willd. (Mabola Ebony : Philippines)
Diospyros discolor, Willd. (Mabola Ebony : Philippines)	Diplothemium caudescens, Mart. (A Brazilian Palm)
Dypsis madagascariensis, Hort' (A Palm : Madagascar)	Dypsis madagascariensis, Hort. (A Palm : Madagascar)
Eletaria Cardamomum, Maton (Cardamon : India)	Elettaria Cardamomum, Maton. (Cardamom : India)
Erythrina umbrosa, H. B. & K. (Bois Immortelle : S. America.)	Entada scandens, Benth. (Cacoon : Tropics)
Erythroxylon Coca, Lam. (Coca : Andes)	Erythrina umbrosa, H. B. & K. (Bois Immortelle : S. America)
Faradaya splendida, F. Muell. (An Australian climber)	Hibiscus elatus Sw. (Blue Mahoe : W. Indies)
Garcinia indica, Choisy (Kokam Butter : India)	Livistona australis, Mart. (A Palm: Australia)
Hevea brasiliensis, Muell. Arg. (Para Rubber : Brazil)	Livistona chinensis, R. Br. (Fan Palm : China & Japan)
Hibiscus elatus, Sw. (Blue Mahoe : W. Indies)	Manihot Glaziovii, Muell, Arg. (Ceara Rubber : Brazil)
Jacaranda filicifolia, D. Don (Fern-leaved Jacaranda : Guiana)	Mimusops Elengi, Linn. (Elengi : E. Indies)
Landolphia florida, Benth. (Rubber Vine : W. Africa)	Musa textilis, Nee (Manilla Hemp : Philippines)
Mesua ferrea, Linn (Naghas Tree : India)	Oreodoxa regia, H. B. & K. (Royal Palm : Cuba)
Michelia Champaca, Linn. (Champac Tree : India)	Pandanus utilis, Bory. (Screw Pine : Madagascar)
Mimusops Elengi, Linn. (Elengi : E. Indies)	Pachyrhizus tuberosus, Spreng. (Yam Bean : W. Indies)
Musa textilis, Nee (Manilla Hemp : Philippines)	Pachira aquatica, Aubl. (Pachira : Panama)
Napoleona imperialis, Beauv. (Napoleona : W. Africa)	Pterospermum acerifolium, Willd. (Maple-leaved Pterospermum : India)
Pachira aquatica, Aubl. (Pachira ; Panama)	Semecarpus Anacardium, Linn. (Marking Nut Tree : India)
Pachira Barrigon, Linn. (Barrigon : Panama)	Strychnos Nux-vomica, Linn. (Nux Vomica : E. Indies)
Pithacolobium dulce, Benth. (Guamuchil : Cent. Amer.)	
Pterospermum acerifolium, Willd. (Maple-leaved Pterospermum : India)	
Quassia amara, Linn. (Quassia : Surinam)	
Stifftia chrysantha, Mikan (Stifftia : Brazil)	
Strychnos Nux-vomica, Linn. (Nux Vomica : Indies)	
Tectona grandis, Linn. f. (Teak : India)	

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SOIL FERMENTS IMPORTANT IN AGRICULTURE.

By Dr. W. H. Wiley, Chief of the Division of Chemistry, U. S. Department of Agriculture, in *Year Book of U. S. Dept. of Agriculture for 1895.*

(Continued).

FALLOW FIELDS.

In former times it was a common practice among farmers to allow a field to lie fallow for one season in order to increase its fertility. The advisability of this process is extremely questionable. During a moderately dry summer there is probably very little loss experienced by ploughing a field after the spring rains and keeping its surface sufficiently well cultivated during the summer to prevent the growth of weeds. In the absence of heavy rainfall the stores of available nitrogen in such a soil will undoubtedly be increased during the summer, inasmuch as the processes of nitrification will be continued and the stores of nitrogen thus oxidized, in the absence of absorbing bodies, will reremain in the soil. Even in case of rainfalls which may carry the soluble plant food below the arable soil, there may not be ony notable loss, especially if such a downpour be followed by dry weather. In the latter case, by the evaporation from the surface and consequent capillary movement of the soil moisture upward, the available plant food carried beyond the reach of the rootlets of plants will be brought again toward the surface and rendered available. But in case of heavy rains, producing a thorough saturation and leaching of the soil, the losses in a field lying fallow during the summer will be very great, and it is not well at any time to take the risk. Especially is this statement true of fields which have lain fallow during the summer and which are afterwards exposed to the saturating rains of the autumn and winter. In these cases the nitrogen will be thoroughly extracted, and all the soluble matters which may have accumulated during the summer will be lost. It is advisable, therefore, in all cases, instead of allowing the fields to lie fallow, to seed them with a catch crop, such as barley, rye, or peas, which may retain the products of nitrification. When the time comes for seeding the field with the intended crop, the catch can be turned under with the plough, and, in the process of decay,

furnish again the nitrogenous food in an available form. This practice should never be neglected in fields which lie over during the winter in preparation for planting during the following spring Of course, this statement does not apply so particularly to fields which may be ploughed late in the autumn, after the activity of the nitrifying ferments is practically suspended for the winter. In a temperate climate fields may be ploughed late in November or during the month of December, and the freshly turned soil be exposed to the action of the weather during the winter without great danger of loss.

In many localities even an earlier period might be chosen for the autumn ploughing, which should be deep or accompanied by sub-soiling. The loosened soil should be brought into good tilth, and thus form an absorbent which will hold large quantities of moisture, becoming available for the following season during the period of deficient rains.

THE SUPPLY OF RAW MATERIAL FOR THE ACTION OF FERMENTS.

A field is as poor as its most deficient fertilizing principle. A plant, like an animal, demands a balanced ration. It can not live upon phosphoric acid alone. In order to secure the most economic method of fertilizing, the peculiarities of each field must be carefully studied and its particular deficiency in plant food determined. In the case under consideration it may happen that a field will have an abundant supply of potash and phosphorus and be deficient only in nitrogen. In such a case its pristine fertility will be restored by the application of nitrogen alone, provided the other conditions in the composition of the soil are favourable to the development and activity of the ferments which oxidize nitrogen. Virgin soils as a rule are extremely rich in nitrogen. This arises from several causes. In the first place, such soils usually contain a large quantity of humus, and this humus is exceptionally rich in its nitrogenous elements. In the second place, a virgin soil is apt to be well protected from leaching. This is secured either by a forest growth or, on prairie land, by the grass. In the third place, there is a well-marked tendency in soils, especially those covered by grass, and presumably those also protected by forest growth, to develop ferments capable of oxidizing the free nitrogen of the air. When virgin soils are subjected to cultivation, it is found that their nitrogen content, as a rule, diminishes most rapidly as compared with that of the other leading plant foods. Hence, it becomes necessary sooner or later, if maximum crops are to be maintained, to supply nitrogenous food. Attention has already been called to the use of the stores of nitrogen which have already been oxidized for fertilization. It is evident, however, that only a very small part of the nitrogenous needs of arable fields can be supplied in this way. Further than this, it must not be forgotten that in the use of a substance like Chili saltpetre, there is added to the soil a material which can in no manner foster the growth and development of nitrifying organism. To feed a soil with a food of this kind alone, therefore. would be to virtually produce a famine in respect to the nitrifying ferments which it contains.

It is therefore highly important that additional methods of supplying the nitrogenous foods of plants should be practised. Stall manures and the refuse of cattle and poultry yards furnish considerable quantities of nitrogenous materials suited to the needs of the soil ferments, and use-

ful after oxidation to the growing crop. In the growth of leguminous plants, as has already been intimated, another important supply of organic nitrogen may be secured, some of which, at least, is a clear, gain from the atmosphere. Other important forms of nitrogenous materials are found in the pressed cakes left after the extraction of the oil from oil-producing seeds, such as flax and cotton seed. These cakes are exceptionally rich in nitrogenous matter which may be secured for the field both by the direct application of the ground material to the soil, or by first feeding it to animals, the part which escapes digestion in the latter case being still a valuable fertilising material. In the case of cotton-seed cake, moreover. it should not be forgotten that there is some danger in feeding it, especially to young cattle, on account of the poisonous nitrogenous bases (cholin and betain) which it contains.

These poisonous bases produce no deleterious effects whatever in the soil, although it is doubtful whether they are attacked very readily by the nitrifying ferments. Other sources of nitrogenous foods for the soil ferments are found in the refuse of slaughter houses. Dried blood is perhaps the richest in nitrogen of any organic substance that is known, and is readily attacked by the soil ferments. The nitrogenous refuse of slaughtered animals, after the extraction of the fat, is dried and ground and sold under the name of tankage. It is a substance very rich in nitrogenous matter. The bones of animals are not only valuable on account of the phosphoric acid which they contain, but also have a large percentage of nitrogenous material which renders them particularly well suited for application to a soil deficient both in phosphoric acid and nitrogen. For this reason, burning bones before grinding them for fertilising purposes, which is done in some localities, is extremely wasteful. For a similar reason, also, the composting of coarsely ground fresh bones with wood ashes is not to be recommended, because of the tendency of the alkali of the ashes to set free, in the form of ammonia, at least a part of the nitrogenous content of the bones.

CONTRIBUTIONS FROM THE OCEAN

The farmer, happily, is not confined alone to the land for the sources of organic nitrogen with which to supply the demands of the nitrifying ferments of his field. The ocean is made to contribute to the stores of nitrogenous matters to which the farmer has acccess. The vast quantities of seaweed which are thrown up annually upon our shores are rich in nitrogenous matters. The value of this material, however, is not generally appreciated, but in some parts of the country it is carefully gathered and utilised. The value of this product gathered annually upon the shores of Rhode Island alone is nearly 100,000 dols. While seaweed, for obvious reasons, can only be successfully applied in marine literal agriculture, yet the extent of agricultural lands bordering on the sea is so great as to render the commercial importance of the matter of the highest degree of interest. Seaweed is not valuable for its nitrogenous constituents alone, but also carries large quantities of potash and phosphoric acid, and thus to a certain degree, it may be regarded as a complete fertiliser. But the seaweed which is thrown upon our shores is not the only source of nitrogenous food which we receive from the ocean. In the animal life of the ocean are gathered vast quantities of nitrogenous materials. The quantity of albuminoid matter in the water-free sub-

stance of the flesh of fish is enormously high as compared with ordinary foods. It may be said to be, approximately, 75 per cent. of the water-free substance. Some varieties of fish are taken alone for their oil product and agricultural value. This is especially true of the menhaden, vast quantities of which are annually brought to land, and after being passed through the oil factory are ground and distributed as fish scrap to the manufacturers of fertilisers. The practice of using fish for fertilising purposes is many centuries old; but until recent years the farmers residing along the coast were the only ones receiving any benefit therefrom. At the present time the nitrogenous elements taken from the sea find their way to the gardens, truck lands, and fields of the interior.

RELATION OF DIFFERENT CROPS TO FERMENTATIVE ACTIVITY.

It is a well-established principle of farming that there are certain crops which cannot be grown continuously upon the same field, while in the case of other crops almost an indefinite growth can be secured. Broadly, it may be said that cereals can be grown upon the same field almost indefinitely and without fertilisation. In such cases, the large crops of cereals which are at first obtained rapidly diminish in quantity until they reach a certain minimum limit, at which point they tend to remain, with variations in yield due only to seasonal influences. On the other hand, root crops of all kinds, and especially leguminous crops, do not continue to flourish upon the some soil, even when liberally fertilised. The necessity for rotation, therefore, is far greater in the latter class of crops than with the cereals. It appears from the result of the scientific investigations attending this difference of behaviour that the relations of these two classes of growing crops are different toward the soil ferments. In the case of the cereals the quantity of nitrogen which they require can be obtained from humus, or other sources, with little effort. In the case of the other class of crops, such as root crops and those of a leguminous nature, it appears that the humus should be particularly rich in nitrogen, and that when by the activity of the soil ferments the percentage of nitrogen is reduced to a certain limit, there is no longer a possibility of a sufficiently vigorous nitrification to meet the demands of the growing vegetables. There is thus a scientific basis, as well as practical reasons, for a frequent rotation of crops. Even in the case of cereals, which, as mentioned above, can be grown with considerable success without rotation, experience has shown that a change from one crop to another is always beneficial.

THE RELATION OF HUMUS TO SOIL FERMENTS.

The term humus is applied to those constituents of the soil which have been derived chiefly from the decay of vegetable matter. In this decay the original structure of the vegetable has been entirely lost, and the residue, in the form of a vegetable mould of a black or brownish colour, is left distributed in the soil. In the processes of decay, the organic matter of the vegetable is converted largely into acids of the humic series, and the nitrogenous principles of the plant become changed from an albuminoid to a more inert form, in which it is more readily preserved. It is this practically inert form of nitrogen on which the soil ferments exercise their activity in preparing it for the uses of the plant. It has been a commonly accepted theory in the past, especially since the time of

Liebig, that the organic principles of humus of every description suffer entire decomposition under the action of fermentative germs before being absorbed as plant nutriment. Recent investigations, however, tend to show that in some instances the organic elements of the humus itself may serve as food for plants without undergoing entire decomposition. Whether or not the nitrogenous principles of the humus can thus be employed has not been determined, but that the humus itself, or some constituents thereof, can be absorbed by the plant I have myself often noticed, especially in the case of sugar cane grown upon a rich vegetable mould. The juices expressed from such canes contain the organic matter of the humus to a certain extent unchanged, and the sugar and molasses made therefrom are distinctly impregnated in the raw state with this organic matter.

These facts have a tendency to raise again the question concerning the mineral character of plant food, which for many years was considered as definitely settled. Recent progress in synthetic chemistry has shown that there is no impassable barrier between organic and inorganic classes of compounds. By the union, for instance, of lime and carbon under the influence of the electric arc, a substance is obtained—calcium carbide—which, when thrown upon water, evolves the gas, acetylene, which was formerly supposed to be wholly of organic origin. In hundreds of other instances the barriers between organic and inorganic substances have been broken down in laboratory, and organic bodies as complicated in their nature as sugars have been formed by pure synthesis. The chemistry of the vegetable organism is admittedly superior to that of the chemical laboratory, and while there is no doubt of the fact that the vast preponderance of vegetable food is of a mineral nature, it would not be safe to deny to the vegetable the ability to absorb to a certain extent organic compounds.

There is, however, at the present time but little evidence to show that organic compounds of a nitrogenous nature are ever absorbed by plants, and therefore, even in the case of humus, we must still contend, at least for the present, that its nitrogenous constituents only become available for plant food after having been fully oxidized by the action of the soil ferments.

DETERMINATION OF THE ACTIVITY OF SOIL FERMENTS.

It is evident from the preceding pages that a study of the soil for agricultural purposes is incomplete which does not include a determination of the character and vigour of the ferments which it contains. This necessarily introduces into the practice of soil analysis the processes of bacteriological examination. It is not the purpose at the present time to describe these processes, but to give only to the general reader as clear an idea as possible of the principles which underlie the analysis of soils for the purpose of determining the activity of their nitrifying ferments.

THE SPRAYING OF PLANTS.

Mr. B. T. Galloway, Chief of the Division of Vegetable Pathology, U. S. Dept. of Agriculture, says in a preface to a work on the above heading by Mr. E. G. Lodeman:—" In looking back over the past 10 or 12 years, it is difficult to realise the rapid advance made in combating the insects and fungi which attack our cultivated plants. It is not going too far to say that the discoveries made within this period have worked almost a revolution in certain lines of agriculture."

Mr. Lodeman's treatise is a very valuable one, and the following extracts are given to explain the importance of the subject:—

" Man's power over the organisms which injure cultivated plants was never so great as it is at the present time. One by one these enemies have been carefully studied, the history of their lives determined, and their habits observed. Only by understanding them thoroughly can proper steps be taken to check their ravages in the most economical and efficient manner; yet it is within comparatively recent years that this first step was taken to obtain the mastery over them. Formerly, when a pest injured a plant, it was no uncommon practice to apply any remedies or materials that came to hand, regardless of their probable efficiency. It was not generally the weakest point of the organism that was assailed. In many cases, it was not even the proper organism which was held responsible for the injury. Nevertheless many valuable discoveries came from these varied and desultory treatments, and some of the remedies most highly prized to-day were discovered merely by chance, not very many years ago.

"Present knowledge and methods of investigation, largely founded upon this experience, enable us to arrive at conclusions which, from the outset, are founded upon a sound and logical basis. It is fortunate that this is the case. The number of the enemies of cultivated plants is either now more numerous than formerly, or the attacks are much more energetic. It is undoubtedly true that the maladies of cultivated plants are much more widespread. This fact is mostly due to the greater food supply, and to the greater ease with which most of the injurious forms can pass from one part of the country to another, because the cultivated areas lie so close together. If a plant is grown to any considerable extent, it is easy for its enemies to spread over the entire region in which it is cultivated. Physical barriers are almost without value in checking this spreading of disease. The ocean is only a partial exception, since such close means of communication have been established between all parts of the globe that this obstacle is now of little avail. Some diseases have not yet been able to overpass it, but as it has proved of little hindrance in so many cases, it is probable that ultimately the enemies and diseases of plants will be as widespread as are the plants upon which they flourish. Weedy plants, insects, and possibly also fungi, are frequently more destructive in a new country than in their old home. They are freed from the enemies or conditions which formerly kept them in check, and in some cases they are the cause of very serious disturbance, although originally they may not have been markedly destructive.

"Farmers and fruit growers cannot fence out the many forms of insects and fungi which live upon their crops, and which are as anxious for a

harvest as the grower is. It is a fight between the grower and the pest, and it must be admitted that the latter has generally had the best of the battle. The farmer has not been properly equipped. He has often had invisible foes to contend with, foes which he did not understand, and which he could not assail. It frequently occurred that an entire crop was ruined in a day or two, and the causes remained unseen and unknown; and even if it was visible, almost the only remedy upon which the grower could rely with certainty was mere force, first catching the pest and then destroying it. As this could be done with profit only in rare cases, it was little better than no remedy, and the general result was that the insect or the fungus obtained an ample supply of nourishment, and the grower took what was left. Indeed. this method is still followed by many cultivators, but it is not the safest nor is it the most profitable one.

"The best is generally the most profitable commodity, and the poorest is the least so; and the grower of to-day has it in his power to produce the best. It rests entirely with him whether his apples shall be wormy or not, whether his trees shall retain their foliage or lose it from disease. There are few evils that affect his crops which he cannot control, in many cases almost absolutely. Only a few diseases remain which still refuse to submit to treatment, but the number is rapidly decreasing, and the time will come when these also will disclose some vulnerable point wnich will allow of their destruction.

"Foremost among the operations by means of which cultivated plants are protected from their enemies is spraying. This consists in throwing upon plants any fluids, or semi-fluids, in the form of a fine rain or mist. It rests upon the general principle of covering the plants, or the parts of plants to be protected, with a thin but uniform layer of some material that is poisonous, caustic, or offensive to the organism which it is desired to destroy....

"Three points cannot be too strongly emphasized:—

"First, be on time. Make an application when it will do the most good, and never allow time to pass if it can possibly be avoided. Every delay is of advantage to the parasite, and it will be used so well that in most cases the injury cannot be repaired. The destruction of one insect may mean the destruction of hundreds, and one application made at the right time may mean, and generally does mean, the protection of a plant against millions of spores and fungi which are endeavouring to gain a foothold. Be ready for action at a moment's notice, and when the moment comes, spray!

"Second, be thorough. When spraying a plant, spray it well. With a little care, a complete success may be obtained instead of only a partial one. When the work is finished, the grower should have the feeling that it is well done, and then no fear as to the result need be entertained. Spraying is not always pleasant work, and the temptation to slight it is often strong; but the operator will be rewarded just to the extent to which he has been painstaking, and to that extent only.

Third, apply sprays intelligently. This is really the most important factor in the work, although good crops can be obtained without it, provided directions are followed. The first two points cannot be neglected without injury to the crops but this one can be. The crop is in need of the applications only, but the grower should know the reasons

for them, and should be in a position to modify his treatment so as to make them conform with the character of the insect or the disease which is being treated, and with the season. Every year and every day such knowledge will be of value. So many things are still unknown, and so many points still in dispute, that personal knowledge and judgment about individual cases are not only desirable, but very essential. Directions covering the majority of cases can be given, but now and then one will come up which seems to differ from all others, and it is then that this knowledge will prove most valuable. A few of the general principles upon which this work rests are mentioned below.

THE ACTION OF INSECTICIDES AND FUNGICIDES.

"The principal organisms against which the cultivator has to contend are insects and fungi. They are widely different in their organization, and entirely different substances are required for their destruction. Any substance which is used to destroy or repel insects may be termed an insecticide; and any substance which destroys fungi, or which prevents their injurious growth on vegetation, is a fungicide. No substance, so far as known, will answer both purposes equally well.

1. UPON INSECTS.

"Practically all the applications which are made to destroy insects are designed to act in one of two ways. The substance may be destined to enter the digestive system of the insect and thus cause death, just as many poisons cause death when taken into the stomachs of higher animals. This method is by far the cheapest, and when possible, it is advisable to make use of it.

"The second method does not consist in putting poison on the food of the insect, but the material is put directly upon the insect itself. It then causes death either by stopping up the breathing pores, or it penetrates the outer coverings and so enters the body directly. This method cannot be used with success against all insects, as some have very tough and dense coverings which are not readily penetrated by any material that we can use for the purpose. Beetles, for example, can scarcely be destroyed in this manner. But all soft-bodied insects, such as aphides, worms, and caterpillars, yield readily to the treatment if sufficient material comes in contact with their bodies.

"This method of killing insects by means of substances which cause death merely by penetrating the creature's body, is rather expensive, and it is resorted to only when the pest cannot be treated by poisoning its food. It thus comes that most worms and caterpillars are destroyed by means of poisons which are eaten, though they yield to the other treatment equally well.

"The food of many insects, however, cannot be poisoned, since they feed upon the juice of plants and do not eat the external coverings. It is fortunate that most of these insects have soft bodies, so that they yield readily to treatment if the poison comes in contact with them. Their mouth parts are formed for penetrating the external coverings of plants to a depth sufficient to reach the sap; just as the mosquitoes' bills are in the habit of penetrating human kind. All aphides belong to this class, as well as the true bugs, these having mouth parts which are adapted to suck, but not to chew. The utter uselessness of cover-

ing a plant with poisons to protect it from these pests will readily be seen. No matter how thick the poison may be, the insect's beak will penetrate this poisonous layer, and it will take no food until the beak has passed the limit of the poison and is deeply buried in the tissues of the plant.

"From the above it will be seen that :

(a) To destroy chewing insects, such as the potato beetle, poison must be evenly distributed over those parts upon which the insects feed, and this may in some cases be done even before the insect is present, or is visible. Only those poisons which cause death after being eaten should be used.

(b) To destroy sucking insects, such as plant lice, the materials must be distributed upon the insects as evenly as possible and it is useless to make any application before theinsect has appeared. Only those poison which kill by coming in contact with the insect's body should be used.

"First determine what kind of a pest it is that needs treatment, then select the proper material.

II. Upon Fungi.

"Among fungi we find many serious enemies. It is difficult to tell just what a fungus is, but some of the principal characteristics may be mentioned. A fungus is a plant; but unlike flowering plants, it possesses no chlorophyll. Chlorophyll is the green-coloured protoplasm found in flowering plants, and it is the only substance we know through which plants change crude food to nutritive material. We must conclude, therefore, that fungi do not prepare their own food, but feed upon organic matter which is already adapted to their wants. They possess no leaves, flowers, nor seeds. That part of any fungus which is of most interest to the horticulturist is composed of long, fine threads, either growing separately or in bundles; these threads are known as hyphæ, and collectively they form the mycelium or vegetative portion of the fungus. The mycelium corresponds to the roots and stems of flowering plants.

"Spores, which are organs performing the same office as the seeds of flowering plants, are produced by this mycelium either directly, or upon branches (sometimes called sporophores) which are thrown out. These sporophores cause the white downy appearance seen upon grape leaves affected with the downy mildew. A spore, strictly speaking, is not a seed, for a seed contains a young plant, while a spore does not, being usually composed of only one cell. If a spore finds the proper conditions of heat and moisture it will germinate and send out a fine filament, which, if nourished, grows on branches, and eventually a plant like the original will be produced.

"Most fungi in the North produce two kinds of spores, known as the summer and the winter spores. The summer spores are usually borne upon the exterior of the host-plant, or the plant on which the fungus grows. These spores ripen quickly and propagate the fungus rapidly. But if they do not germinate soon after ripening they lose their vitality.

"The winter spores are usually produced within the tissues of the host-plant, commonly in the leaves and fruit. They are the spores which live through the winter; but in the spring, under favourable circumstances, they germinate, and thus the fungus is again developed.

"Fungi may be divided into two general classes: those growing upon dead and decaying matter, or saprophytes; those feeding upon living tissue, or parasites. By far the larger portion possessing interest to the horticulturist belong to the latter class, for in this are included the fungi which do so much injury to cultivated plants.

"Yet all parasitic fungi do not attack the host-plant in the same manner. Some immediately penetrate into the interior tissue, and there they flourish, being well protected from outer influences by the exterior covering of the plant The fungi causing all the more serious diseases develope in this matter and in fact, the vast majority of plant diseases are caused by such organisms. There are others, however, in which the body of the fungus is almost entirely upon the surface of the host-plant, only a comparatively small number of threads penetrating the tissues in order to obtain nourishment. These parasites can be rubbed off, and unless the attack has been very severe, the green, healthy tissue will be seen underneath. This class may for convenience be termed "surface fungi;" to distinguish them from those which grow within the host-plant; it is represented by the common powdery mildew of the grape, one mildew of the gooseberry, one of the strawberry, and a few others.

"The life histories of the various fungi must form the basis for any methods of treatment which may be adopted. During certain stages of their existence, parasitic fungi may be checked quite easily, and at such times the remedies should be applied.

"It is evident that when a fungus has once become established inside the host-plant, it cannot be reached without destroying the tissue of the host in the affected places, which is by no means desirable. The fungus must be destroyed before it enters the host; in other words, the spores must be killed as soon as they germinate or better they must not be allowed to germinate. All applications must be preventive, not curative, since a cure is practically impossible when the fungus is once established, unless it grows upon the surface of the host.

"The line of treatment indicated is this: to cover the stems and foliage of the cultivated plant with some substance that will destroy the spores which may be present, as soon as they germinate, or with one that will have the power of preventing this germination. If that is done, the plant will remain healthy, so far as fungi are concerned; otherwise it will not, unless, indeed, no fungus attacks it. Several substances which destroy these spores, as well as the surface fungi, have already been found. They are easily applied, safe, and effective, and any grower who suffers his fruit to be ruined by these parasites is, as a rule, deserving of his loss, for means of destroying the pests are at his command. It is largely the grower's fault if his apples are scabby, if his grapes are mildewed, and if his potatoes rot in the field. Spraying is no longer an experiment, it is a necessity; and those who recognize this fact are the ones who are reaping the rewards.

SPRAY MACHINERY.

"The best spray nozzle, so far as efficiency, simplicity, and cheapness are concerned, is the end of a hose and a man's thumb. Unfortunately the thumb gets sore and tired, and operations must be suspended to wait for repairs. It is the nearest approach to the ideal nozzle yet devised, if it were only more practicable. It will do all that a good

nozzle should do. It throws a fine mist-like spray, one that will "float in the air like a fog," or the particles of water may instantly be made coarser, and the water thus carried to a greater distance; or still coarser and the water leaves the hose in the form of a solid stream. These changes all take place instantly (after a little practice), and it makes no difference whether the parts to be sprayed are a few inches or many feet away. This nozzle never clogs, but is cleaned automatically, and as quickly as the character of the spray is varied. In fact it possesses all the desirable qualities of a spray nozzle, except durability, and for this we must turn to the metals for aid.

"All operators do not desire the same kind of spray even for the same kind of work. It is commonly said that the best spray is one which most nearly resembles a fog That is true so far as the spray is concerned, but the trouble comes in applying it. A fine spray cannot be applied so advantageously as a coarser one, nor can it be applied so rapidly for the reason that the finer the spray the less liquid is thrown, and the smaller the area treated. Whenever the wind blows, a fog-like spray will go wherever the wind carries it, and not where the operator directs it. Sometimes this will be an advantage. It is especially so when the wind is blowing in the right direction. Yet when the other side of the tree is being treated the wind will come from the wrong direction, and much of the material is blown where it is not wanted. In addition to this, the work is more slowly performed, and whether it is more thoroughly done than when a coarser spray is well used is still open to doubt. After having tried both kind of sprays, it appears to the writer that if the parts to be treated are close by, a fine spray is to be preferred, as then there is less waste and an even application may be made. If the parts to be treated are more removed, being situated from ten to twenty-five feet away, a coarser spray is wanted;—the more distant the object, the coarser the spray. The work can thus be done much more rapidly, just as effectively (with the exception of some waste), and much more satisfactorily, than by the use of a fine spray. In case a fine spray is used, it is necessary to have a pole to carry the nozzle to the different parts of the tree, and this is as tedious as it is unpleasant. When a coarser spray is made, there is generally formed enough of the finer spray to float in the air and protect parts which are not directly reached by the operator.

"The finest sprays are produced by the eddy-chamber nozzles and by those in which two streams of water strike each other at an angle. With such nozzles, the spray can be made as fine as desired, the size of the outlet orifice being the main controlling factor. For long-distance work, when the liquid is to be carried ten feet or more, the best spray is formed when the fluid is forced through two flat, parallel, metal surfaces. The greater the pressure, the greater will be the amount of fine spray and the farther will it be thrown. Although the ideal nozzle has not yet been made in metal, some of the forms now sold are approaching perfection.

"All good spray machinery is expensive, and only careless operators will neglect the ordinary methods of preserving it as long as possible. When the pump has been used in applying any of the preparations, with the exception of clear water, it should be cleaned. No insecticide nor fungicide should be allowed to stand within the pump,

but clear water should be pumped through it before it is put away. It is well to oil all the working parts occasionally, as a little oil at times may prevent the metal from being cut, and the pump will be thus preserved much longer than otherwise. Nozzles are also benefited by the same treatment. Oil can scarcely be used too freely on the inside of such apparatus, and an occasional coat of paint on the outside will assist materially in protecting the metal. The careless man pays dearly for his neglect."

Mr. B. T. Galloway in the Bushberg Catalogue Grape Manual says:—

"It has been pointed out in various publications by the writer that a sprayer to be effective requires first of all a good strong force pump. Next in importance is a nozzle that will throw a mist-like spray and will not clog when thick fluids are used. There are plenty of machines on the market filling all these requirements. For convenience they may be divided into three classes: (1) horse power automatic machines; (2) machines drawn by horse power, but operated by hand; and (3) hand machines. All belonging to the first group are unnecessarily expensive and complicated, and will not do the work as thoroughly and effectively as the machines belonging to the second and third groups.

Of the second group, in which the cheapest and most practical and efficient example is found in a strong, light, double acting double-discharge force pump, mounted on a barrel, it may be said that while they cannot do the work as rapidly as the machines of the first class, they are more effective, much cheaper, and far less wasteful of the liquid used.

"To the third class belong the knapsack sprayers, which are the only ones necessary to notice in this connection. There is no question that for all moderately low-growing crops the knapsack sprayer fills every requirement. In no other machine is the work so absolutely at all times under control, it being possible to place nearly every drop of the liquid exactly where it is needed. Knapsack pumps are now used in many moderate sized vineyards, also in places where the horse-power apparatus, owing to the nature of the land or the manner of cultivation, cannot be utilised.

"Many firms throughout the United States are engaged in the manufacture and sale of the various machines mentioned.

"For applying sulphur various devices are in use. Probably the simplest is that employed by the grape growers of California, *i e.*, a tin can holding about a gallon, provided at the top with a strong, rigid handle, and having the bottom punched full of small holes. Owing to the manner in which the vines are trained, two rows can be treated at a time by one man. A can containing sulphur is simply held in each hand and given a slight twist over a vine in each row. This scatters the sulphur over the entire plant and the operator then passes to the next two vines. Of course this plan could not be followed in the East, owing to the way in which the vines are trained. Various styles of sulphuring bellows have been designed for the work."

Spray machinery can be obtained from the United States through various merchants.

The following articles on Fungicides, Fungous Diseases of the Grape, are adapted from Messrs Galloway & Lodeman's works:—

FUNGOUS DISEASES OF THE GRAPE.

Anthracnose.

(Sphaceloma Ampelinum, De Bary.)

Description.—This is a fungus which attacks all parts of the Grape Vine, but most commonly the berries. The name, anthracnose, means coal-disease, the disease is so-called from the dark colouration of the affected parts.

When it first attacks the berries, circular brown spots are noticed, with a somewhat sunken surface, gradually enlarging in size. If there are several spots on the berry, they grow into one another, forming a large patch with an irregular line. As the disease progresses, the skin of the centre spot may form a scab of a lighter colour—grayish and sometimes with a band of vermilion colour outside the centre.

It will probably be first apparent on the shoots of the vine, on which the spots extend lengthwise, giving them a speckled appearance when abundant.

It also attacks the leaves and especially the veins and stalks. The stalks of the clusters are often affected too, and when completely girdled, all the berries below the disease-ring remain green, and shrivel up.

Treatment.—When it is known that a vinery is liable to be attacked by this and other fungous diseases, spraying with Bordeaux mixture should be commenced as soon as the first leaves have fully expanded. The second application may be made after flowering, and the third from 2 to 4 weeks later, according to whether the weather is favourable to the disease. The Bordeaux mixture may safely be used until the berries are three-fourths their full size. After that the application may leave a stain which would reduce their market value, and it is better to use the ammonical carbonate of copper about every 10 days even after the fruit is fully formed, if the disease is rampant.

The clusters should be sprayed as well as the leaves, especially when they are young. The reason for several applications is that the spores of the fungus resist successfully every destructive agency, and it is only when they have already germinated that they can be killed. Everything depends upon the thoroughness of the spraying, and each vine should receive about one quart of liquid at each application.

Besides the use of the Bordeax mixture, it is customary to treat the vines in the winter months when they are bare of leaves and dormant, with the sulphuric acid and sulphate of iron solution, applied by means of a brush or a swab made of rags tied round the end of a stick. The effect on the wood is to blacken it which is looked upon as a test of the thoroughness of the work, and whenever the colour remains after 2 or 3 days, a second application should be made.

Black Rot.

(Loestadia Bidwellii, V. & R. ; Phoma uvicola, B. & C.)

The Black rot is even more destructive than the "anthracnose," and besides causing the rotting of the fruit, attacks the leaves and shoots.

Description.—It is readily distinguished from anthracnose by the centre of the dark disease spots having a number of minute pimples,

from which the sporos come, and are carried by the lightest breeze to other berries and to other parts of the vine.

It does not attack the stalks of the clusters, as in anthracnose; and on the leaves it is found originating between the veins, not on them, and has minute pimples in a band near the edge of the affected part.

Grapes are nearly or quite full grown when the disease appears. The spots are first purplish-brown, the whole berry then becomes affected and gradually turns black and the pimples make their appearance. The grape at the same time shrivels, but does not fall off, and the seeds are clearly seen under the skin which become drawn and ridged.

Treatment.—Bordeaux mixture should be used, first before the buds open, a second time when the leaves are one-third grown, a third time just before flowering, a fourth time two weeks later. The fifth application two weeks later should be the ammoniacal copper carbonate solution, and a sixth application of the same may be necessary. If the weather is dry, the number of sprayings may be less.

Downy Mildew, Brown Rot.

(Peronospora viticola, De Bary.)

Description.—Although this downy mildew, attacks all parts of the vine, the chief mischief is when the leaves are diseased, as then not only the present, but next year's crop is in danger.

The leaf first turns lighter green where diseased, then yellow, and lastly brown, while if the under surface is examined when the upper has begun to turn yellow, it will be found to be covered with minute threads growing out from the substance of the leaf.

The grapes are usually attacked before they are half-grown, first turning brown (brown rot), and afterwards grayish (downy mildew).

Treatment.—If the downy mildew is feared the shoots should be first sprayed with Bordeaux mixture when they are only from six to ten inches long, and afterwards on flowering and at intervals of from 2 to 4 weeks.

Powdery Mildew.

(Uncinula spiralis, B. & C.

Description.—This fungus spreads only on the outside surface of the vine though it sends suckers into the cells immediately below, feeding on their contents and changing the green colour into brown. The fungus itself is of a grayish white colour, and easily rubs off the leaf, shoot, or grape, when the destruction of the green colour is very noticeable. It is generally found on the upper surface of the leaves, which distinguishes it from the Downy Mildew. It develops best during dry weather.

Treatment.—As this is only a surface fungus, not penetrating beyond the outer cells, it is not so dangerous as those previously mentioned, and the vines do not require treatment for it, until it has actually made its appearance.

Sulphur is applied either dry or mixed with water, but this remedy is not considered so valuable as spraying with carbonate of copper dissolved in ammonia.

European Mildew.

(Oidium Tuckeri, Berkl.)

Description.—This mildew resembles the Powdery Mildew in general appearance, and like it, is a surface mildew. When it attacks the fruit, the skin of the grape is unable to expand, and bursts.

Treatment.—Flowers of sulphur dusted over the diseased parts effectually disposes of this fungus.

Rattles; Shelling.

Description—Just as the grapes are ripening, they begin to fall off, and this takes place first at the extremities.

Treatment.—As the chief cause of this diseace is defective nutrition, manure should be applied, and especially potash.

Ripe Rot.

(Glœosporium fructigenum, Berkl.)

Description.—The grapes are attacked in the ripening stage. A reddish-brown spot first appears which gradually spreads over the whole grape, then black pimples appear which are not so numerous as in Black Rot, but they are broader.

The colour remains dark purplish brown, and the diseased grapes fall to the ground; whilst in Black Rot, the colour is black, and the grapes do not fall off.

Treatment.—If there are only a few vines, the grapes affected may be picked off and burnt, but where there are a large number, the same treatment should be adopted as for Black Rot.

FUNGICIDES.

Bordeaux Mixture.

Bordeaux Mixture is best made according to the following formula :—

Copper Sulphate	...	6 pounds
Unslacked Lime	...	4 pounds
Water	...	50 gallons

It requires careful mixiug, or the ingredients will not combine properly. Put 25 gallons of water into a barrel. Tie up 6 pounds of copper sulphate in a piece of coarse sack, and hang this by a stick laid across the top of the barrel so as to be just beneath the surface of the water until it has slowly dissolved

In another barrel slack 4 pounds of lime very slowly and carefully, at first only adding about a quart of water at a time, nntil a perfectly smooth paste free from grit, is obtained. Add water to make the whole 25 gallons, and wait until cool. Now pour both together into a cask holding 50 gallons. The milk of lime should be thoroughly stirred before pouring, and finally the mixture should be well stirred for 4 or 5 minutes with a wooden paddle.

If not perfect, the mixture is liable to injure the foliage and in order to test this, put the blade of a penknife into the mixture and leave it for 1 or 2 minutes. If there is any deposit of copper on the blade, showing a brownish colour, it is not safe to use it, and more lime must be added until the knife is not discoloured.

Ammoniacal Copper Carbonate Solution.

Penny has made a very careful study of the best method of preparing this solution, and the results of his work are here given in full :—

"The practical directions are these: To 1 volume of 26° Beaumè ammonia (the strong ammonia of commerce) add from 7 to 8 volumes of water. Then add copper carbonate, best in successive quantities, until a large portion remains undissolved. The mixture should be vigourously agitated during the solution and finally allowed to subside and the clear liquid poured off from the undissolved salt. A second portion should then be made by treating the residue of the former lot with more ammonia diluted as before, then with the addition of fresh copper carbonate, in every case with vigorous stirring or agitation. This method of making in successive lots will result in a richer solution of copper, at least, unless an unwarranted length of time be taken. This soution may be made in any suitable wooden or stoneware vessel.

"A still better way is to place in a large jar an inverted crock, or other suitable shelf, and on this the copper carbonate, so that it shall be at the surface of the ammonia when it is poured in. After adding the ammonia, diluted as above, the whole should be allowed to stand covered some time, as over night, and then the undissolved copper salt may be in great part easily lifted out of the solution. Instead of the shelf a suitable receptacle may be used, as a fine wire sieve. The jar will need nothing but a loose cover, as the loss of ammonia will be slight at that degree of dilution.

"The clear solution thus obtained, containing from three to four per cent. of ammonia gas, must be diluted as described above, in no case less than 13 or 15 fold, better, for the safety of the plant, 20 fold or more.

"Those directions which recommend so much ammonia, (whatever it may be) to be used as may be necessary to dissolve the copper salt and then to dilute to a given number of gallons, are not only not economical, but absolutely dangerous, in as much as it is an uncertainty just how much ammonia may be used in the first instance, and hence uncertain what strength it may have after dilution, when applied to the trees. It should be borne in mind always that if strong ammonia is used it must be diluted from first to last at least 100 fold, and better considerably more.

"The solubility of copper carbonate in ammonia carbonate has been studied but not yet sufficiently for report.

After the copper carbonate has been dissolved in ammonia water, it should be used by taking as much of the fluid as contains 1 ounce of dissolved copper carbonate, and this is then diluted with 9 gallons of water. These proportions should be retained when either larger or smaller quantities of the fungicide are desired.

The ammoniacal solution of copper carbonate possesses some decided advantages. It is a clear solution entirely free from sediment, and can therefore be applied as readily as water. Another favourable point is that it may be used quite freely upon maturing fruit, and also upon flowering plants, without leaving any conspicuous stain. When certain plants require spraying with a fungicide shortly before the crop is harvested, this preparation is an excellent one to use. In efficiency it also ranks high, being clearly surpassed in this respect only by the

Bordeaux mixture. It is also cheap, and on the whole is one of our most valuable remedies.

Sulphate of Iron (Copperas or Green Vitriol.)

Against anthracnose of the grape the following application has shown itself to be of great value, and it is regularly used by European vineyardists.

Water, (hot), 100 parts
Iron Sulphate, as much as the water will dissolve.
Sulphuric acid, 1 part.

Great care should be exercised in using this preparation, as it is exceedingly caustic and will injure machinery, clothes, and nearly everything with which it comes in contact. It is generally applied with a swab made by tying rags about the end of a stick. Dormant vines are uninjured by the treatment.

JUTE.

Whilst Jute will grow upon any kind of soil, it is found in India that it is only profitably cultivated on a loamy soil or rich clay and sand in a hot damp climate in which the rainfall is not too heavy.

Jute has been tried in several parts of India, but without success except in the northern and eastern part of Bengal and in Assam. In Burma the only difficulty is the cost of labour.

The preparation of the soil is costly as it requires to be ploughed from four to six times before sowing the seed. In about 3¼ months from sowing, it flowers, and is then ready for reaping.

The average crop of fibre is 11 cwt., per acre, but the yield varies enormously according to season and district, sometimes being as high as 24 cwts., and again as low as 2 cwt. "The fibre is separated from the stems by a process of retting in pools of stagnant water. In some districts the bundles of jute stems are submerged in rivers, but the common practice seems to be in favour of tanks or roadside stagnant pools. The period of retting depends upon the nature of the water, the kind of fibre, and condition of the atmosphere. It varies from two to twenty-five days. The operator has therefore to visit the tank daily, and ascertain, by means of his nail, if the fibre has begun to separate from the stem. This period must not be exceeded, otherwise the fibre becomes rotten and almost useless for commercial purposes. The bundles are made to sink in the water by placing on the top of them sods and mud, when the proper stage has been reached, the retting is rapidly completed. The cultivator standing up to the waist in fœtid water, proceeds to remove small portions of the bark from the ends next the roots, and, grasping them together, he strips off the whole with a little management from end to end without breaking either stem or fibre. Having brought a certain quantity into this half-prepared state, he next proceeds to wash off; this is done by taking a large handful, swinging it round his head he dashes it repeatedly against the surface of the water and draws it through towards him so as to wash off the impurities; then with a dexterous throw, he spreads it on the surface of the water and carefully picks off all remaining black spots. It is now wrung out so as to remove as much

water as possible, and then hung up on lines prepared on the spot, to dry in the sun".—(Royle in Watts Dictionary.)

The price paid to the cultivator varies from 4 to 5 shillings per cwt.

Jute is obtained from *Corchorus olitorius* near Calcutta, and *Corchorus capsularis* in other parts of Bengal.

The young shoots of *Corchorus olitorius* are used throughout India as a pot-herb, and for the same purpose as "Jews Mallow." This species is naturalised in Jamaica.

The native species are *C. siliquosus*, *C. æstuans*, and *C. hirsutus*; the first named being commonly called "Broom-weed" from the use to which it is put.

FERNS: SYNOPTICAL LIST—XLII.

Synoptical List, with descriptions, of the Ferns and Fern-Allies of Jamaica. By G. S. JENMAN, *Superintendent Botanical Garden, Demerara.*

Series II. Exinvolucratæ.

(Sori devoid of involucres.)

TRIBE XI. Polypodieæ.

Sori round or oval, rarely linear or decumbent and confluent, usually smaller than a pin's head but often larger; receptacles the same shape, on the back, or terminal on the veins: sporangia stipitate, compressed arched by an incomplete jointed vertical band, which splits at length transversely; involucres none; veins free, united or variously anastomosing, with or without free included branches in the meshes, fronds few or many, varying from simple-entire to decompound; stipites articulated or not, paced or tufted on a creeping or upright rootstock, the variations or diversity in which are as wide as in the character of the fronds.

A very extensive group, comprising in its members great variety of habit and form, but which as here regarded, constitutes but a single composite genus, distinguished by the naked exposed, usually isolated roundish sori, in all cases devoid in any degree, of an involucre.

GENUS XXX. *Polypodium* Linn.

Only genus see characters of Tribe.

The largest genus of all in the order, spread over the tropical and temperate zones of both hemispheres, most abundant at high elevations within the equatorial belt; the majority epiphytal, affecting the shady moist situations, of the cool higher mountain regions.

I. Veins free.

Fronds entire (or furcate)

1. P. Fawcettii, Baker.
2. P. dendricolum. Jenm.
3. P. gramineum, Swartz.
4. P. nigro-limbatum, Jenm.
5. P. marginellum, Swartz.

Fronds serrulate or lobate in the lower half, entire or serrato-entire in the upper.

6. P. serrulatum, Mett.
7. P. Jamesonii, Jenm.
8. P. myosurioides, Swartz.

Fronds uniformly lobed, pinnatifid or pinnate.
Segments monosorous.

9. P. Sherringii, Baker.
10. P. nimbatum, Jenm.
11. P. exiguum, Grisb.
12. P. trichomanoides, Swartz.
13. P. basi-attenuatum, Jenm.
14. P. tœnifolium, Jenm.
15. P. nutatum, Jenm.
16. P. Hartii, Jenm.

Segments polysorous.
Fronds tapering at the base, subsessile, or petioles not exceeding 1½ in l.
Fronds under 6-9 li. w.

17. P. moniliforme, Lag.
18. P. saxicolum, Baker.
19. P. albo-punctatum, Baker.
20. P. lubæforme, Kaulf.

Fronds from ½-1¼ in. w.

21. P. rigescens, Bory.
22. P. heterotrichum, Baker.
23. P. pendulum, Swartz.
24. P. lasiolepis, Mett.

Fronds from ¾-2 in. w. or over.

25. P. cultratum, Willd.
26. P. cappilare, Desv.
27. P. graveolens, Baker.

Fronds not, or little reduced at the base, petioles 1—several in. l.
Fronds ¾-3 in. w.

28. P. curvatum, Swartz.
29. P. Otites, Swartz.
30. P. trifurcatum, Linn.
31. P. Eggersii, Baker.
32. P. suspensum, Linn.
33. P. asplenifolium, Linn.
34. P. brunneo-viride, Baker.
35. P. firmum, Klotzsch.
36. P. taxifolium, Linn.

Fronds 1-6 in. w.

37. P. Plumula, H. B. K.
38. P. pectinatum, Linn.
39. P. Paradisææ, L. & F.
40. P. simile, Linn.
41. P. dissimile, Linn.

Fronds pinnate, petioles winged to the base.

42. P. microchasum, Baker.

Fronds not articulated at the base of the stipe; pinnate or bipinnate*. —Phegopteris, Fée.*
Fronds simply pinnate.

43. P. hastæfolium, Swartz.
44. P. flavopunctatum, Kanlf.

45. P. pubescens, Radd.
46. P. gracilentum, Jenm.
47. P. ctenoides, Fée.
48. P. Thomsonii, Jenm.
49. P. decussatum, Linn.
50. P. caudatum, Kaulf.

Fronds decompound.

51. P. punctatum, Thunb.
52. P. rugulosum, Gabill.

II. Veins united.

Fronds not articulated at the base of the stipe. Goniopteris, Presl.

Fronds pinnate or bipinnatifid ; opposite veins uniting with a branch running to the veins.

53. P. nigrescentium, Jenm.
54. P. obliteratum, Swartz.
55. P. crenatum, Swartz.
56. P. tetragonum, Linn.

Fronds articulated at the base of the stipe, leaving a clean scar at parting.

Fronds pinnatifid or pinnate.

Fronds coated with matted scales, veins areolate in 1–2 series, with free exterior branches—Lepycistis, J. Sm.

57. P. incanum, Swartz.
58. P. thyssanolepis, R. Br.
59. P. squamatum, Linn.
60. P. lepidopteris, Kze.

Veins areolate, hexagonal, in one to several series, with usually rather stronger primary veins running from the costæ to the margin, exterior branches free; sori terminal on free included veinlets.—Goniophlebium, Blume.

61. P. loriceum, Linn.
62. P. Chnoodes, Spreng.
63. P. attenuatum, H. B. K.
64. P. neriifolium, Schk.
65. P. surrucuchense, Hook.

Veins forming copious narrow elongated angled areolæ, with or without stronger primary veins, costal series transverse to the rest: sori terminal on simple or united included veinlets or compital.—Phlebadium, R. Br.

66. P. aureum, Linn.
67. P. decumanum, Willd.

Areolæ 1–2 serial; pinnæ linear strict. Pleopeltis, Hamboldt.

68. P. retrafolium, Jenm.

Fronds simple entire.

Primary veins costæ-form, raised, parallel, the intervening areolæ fine and uniform; sori compital, large, uniserial between the primary veins.—Pleuridium, Fée, J. Sm.

69. P. crassifolium, Linn.

Primary veins generally as in Pleuridium but connected by transverse, mostly arcuate slender veins, which together form oblong areoles, in 2-several series, containing usual-

ly 2 erect free soriferous branches, divided or not by a slender intermediary veinlet.—Campyloneuron, Presl.

70. P. Phyllitidis, Linn.
71. P. costale, Kunze.
72. P. lævigatum, Cav.
73. P. repens, Linn.
74. P. augustifolium, Swartz.

Areolæ copious, no distinctly costate veins, sori uniserial various genera of authors.

Fronds scaly.

75. P. piloselloides, Linn.

Fronds glabrous.

76. P. vaccinifolium, F. & L.
77. P. lycopodioides, Linn
78. P. Swartzii, Baker.

Fronds scaly.

79. P. lanceolatum, Linn.

CONTRIBUTIONS TO THE DEPARTMENT.

Library.

Catalogue of African Plants collected by Dr. Welwitsch. [British Museum.
Bulletin Royal Gardens, Kew. Jan., 1897. [Kew.]
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Barbados Agri. Gaz. and Planter's Journ. Jan., 1897. [Secy.]
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Hawaiian Planters' Monthly. Jan., 1897. [Editor.]
Report Dept. of Agri., Brisbane. 1895-96. (Dept. of Agri.]
Annual Exchange Catalogue, Field Col. Museum, Chicago. [Director.]

Plants.

From Mr. Henry Pfister, Washington, D.C., U.S.A.
Myriophyllum proserpinacoides, Gill.

Seeds.

From Royal Botanic Gardens, Trinidad.
Sacoglottis amazonica

From Secretary Colonia Cosme, Paraguay
Orange
"Grape Fruit"

From Dept. of Agri. Washington, D.C.
Citrus trifoliata

From Botanic Gardens, Bangalore.
Cryptostegia grandiflora

From Prof. O. Comes, Portici.
Sumatra Tobacco
Shiraz Tobacco
Manilla Tabacco
Herzegovina Tabacco
Hungarian Tobacco

From Mr. A. Libert, Trinidad.
Ptychospernna Alexandræ
Areca triandra
Stevensonia grandifolia
Pritchardia pacifica

CASTLETON GARDENS.

April.

In Flower.	In Fruit.
Baphia nitida, Lodd. (Cam-wood; W. Africa) Brownea Rosa-de-monte, Berg. Caryocar nuciferum, Linn. (Souari, or Butter Nut; Guiana) Cassia glauca, Lam. (Glaucous Cassia; East & West Indies) Castilloa elastica, Cerv. (Central American Rubber; Centr. America) Chrysalidocarpus lutescens, H. Wendl. (A Madagascar Palm) Chrysobalanus Icaco, Linn. (Coco-plum; West Indies) Cocos botryophora, Mart. (Brazilian Palm) Coccoloba uvifera, Linn. (Seaside Grape; W. Indies and Trop. America) Coffea liberica, Hiern. (Liberian Coffee; W. Africa) Copernicia cerifera, Mart. (Wax Palm; Brazil) Couroupita Guianensis, Aubl. (Cannon Ball Tree; Guiana) Dalbergia Sissoo, Roxb. (Sissoo; India and Afghanistan) Dillenia indica, Linn. (Dillenia; E. Indies) Erythrina Crista-galli, Linn. (Scarlet Coral Tree; Brazil) Eugenia caryophyllata, Thunb. (Clove; Moluccas) Fagræa obovata, Wall. (E. Indies) Garcinia indica, Choisy. (Kokam Butter; India) Gynocardia odorata, R. Br. (Chaulmugra; Malay Peninsula) Hevea brasiliensis, Muell, Arg. (Para Rubber; Brazil) Hippomane Mancinella, Linn. (Manchineal tree; West Indies & Trop. America) Hydnocarpus venenata, Gærtn. (Makooloo; India & Ceylon) Mesua ferrea, Linn. (Naghas Tree; India) Michelia Champaca, Linn. (Champac tree; India)	Diospyros discolor, Willd. (Mabola Ebony; Philippines) Dillenia indica, Linn. (Dillenia; E. Indies) Fagræa obovata, Wall. Oreodoxa regia, H. B. & K. (Royal Palm; Cuba) Myristica fragrans, Houtt. (Nutmeg; East Indies)

APRIL, *contd.*

IN FLOWER.	IN FLOWER.
Pachira aquatica, Aubl. (Pachira ; Trop. America) Pachira Barrigon, Seem. (Barrigon ; Panama) Phyllanthus Emblica, Linn. Posoqueria longiflora, Aubl. Pterocarpus indicus, Willd. (Rosewood ; E. Indies & China) Ravenala madagascariensis, J. F. Gmel. (Traveller's Tree ; Madagascar) Samadera indica, Gærtn. (Samadera ; India and Ceylon) Saraca indica, Linn. Shorea robusta, Gærtn. (Sal Tree ; India) Simaruba glauca, D.C. (Bitter Dan ; West Indies) Sterculia carthagensis, Cav. (Chica ; Trop. America)	

MAY.

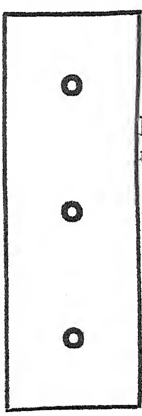
IN FLOWER.	IN FRUIT.
Amherstia nobilis, Wall, (Amherstia ; India and Malacca) Arenga saccharifera, Labill. (Sugar Palm ; Malay Archipelago) Averrhoa Bilimbi, Linn. (The Bilimbi ; East Indies) Baphia nitida, Lodd. (Camwood ; W, Africa) Bassia latifolia, Roxb. (Mahwah Tree ; India) Brownea Rosa-de-monte, Berg. Cæsalpinia Sappan, Linn. (Sappan wood ; East Indies) Castilloa elastica, Cerv. (Central America Rubber ; Centr. America) Chrysalidocarpus lutescens, H. Wendl. (A Madagascar Palm) Couroupita Guianensis, Aubl. (Cannon Ball Tree ; Guiana) Cratoxylon polyanthum, Korth. Diospyros montana, Roxb. Diplothemium caudescens, Mart. Eugenia javanica, Lam. (Wax Jambo ; Malay Islands) Eugenia malaccensis, Linn. (Malay Apple ; Malay Islands)	Astrocaryum vulgare, Mart. (Tucum Palm ; Brazil) Diospyros discolor, Willd. (Mabola Ebony ; Phillipines) Duranta Plumieri, Jacq. Eugenia malaccensis, Linn. (Malay Apple ; Malay Islands) Garcinia Mangostana, Linn. (Mangosteen ; Malay Archipelago) Gmelina asiatica, Linn. Hevea brasiliensis, Muell. Arg. (Para Rubber ; Brazil) Mimusops Elengi, Linn. (Elengi ; India) Michelia Champaca, Linn. (Champac Tree ; India) Musa coccinea, Andr. Nephelium Lit-chi, Cambess (Lit-chi Tree ; South China) Pachira aquatica, Aubl. (Pachira ; Trop. America) Pachira Barrigon, Seem. (Barrigon ; Panama) Pithecolobium Saman, Benth. (Guango ; Tropical America) Phœnix acaulis, Buch.—Ham. (Stemless Palm ; Bengal to Burma) Samadera indica, Gærtn. (Samadera ; India & Ceylon)

IN FLOWER.

Garcinia Mangostana, Linn.
(Mangosteen; Malay Archipelago)
Gmelina asiatica, Linn.
Hydnocarpus venenata, Gærtn.
(Makooloo; India & Ceylon)
Lagerstrœmia Flos-reginæ, Retz.
(Queen's Flower; India and Burma)
Landolphia Kirkii, Dyer
(Rubber Vine; Africa)
Mesua ferrea, Linn.
(Naghas Tree; India)
Mimusops Elengi, Linn.
(Elengi; E. Indies)
Musa rosacea, Jacq.
Nephelium Lit-chi, Cambess.
(Litchi tree; South China)
Norantea Guianensis, Aubl.
(Norantea; Guiana and Brazil)
Pachira aquatica, Aubl.
(Pachira; Trop. America)
Pachira Baarigon, Seem.
(Barrigon; Panama)
Platymiscium polystachyum, Benth.
Vanilla planifolia, Andr.
(Vanilla; Trop. America)

IN FRUIT.

Sapindus marginatus, Willd.
(Soap-berry Tree; W. Indies and Trop. Amer.)
Shorea robusta, Gærtn, f.
(Sal tree; India)
Spondias lutea, Linn.
Vanilla planifolia, Andr.
(Vanilla; Trop. America)



EASY WAY OF BINDING THE BULLETIN.

Get a strip of wood $\frac{1}{4}$ inch thick, $\frac{1}{2}$ inch broad, 10 inches long, bore three $\frac{1}{4}$ inch holes in it, one in the middle and the others 2 inches from the ends.

Lay the strip of wood along the left hand edge of the book, and with a pencil make a dot through each hole; then with a sail needle draw a bit of red tape, 10 inches long, through at each mark, and tie it in a bow. As every fresh number arrives, loosen the bows, one at a time, and with a sail needle and marker add the new number. The book thus made opens well.

O. B. in Agri. Jour. of Cape.

JAMAICA.

BULLETIN

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MANURES AND ORANGES.

Fertilisation of the Soil as Affecting the Orange in Health and Disease.

By H. J. Webber.

Assistant in Division of Vegetable Pathology, U. S. Department of Agriculture, in *Yearbook of the U. S. Dept. of Agriculture for 1894.*

Probably the most important question which concerns the orange grower is how to fertilise his trees. In Florida, where the orange soils are mostly very sandy and sterile, and require to be fertilised regularly, it is highly important to understand what elements should be used in fertilisation and in what forms it is best to use them. No plant will long withstand improper treatment. In case of slow-growing plants like the orange, where proper treatment prolongs growth and productiveness for centuries, it becomes particularly necessary that correct methods of manuring be used. The condition of tree reflects largely the cumulative treatment of years; in crops which are replanted each year, however the effect of improper fertilisation is probably less noticeable, especially so far as the devolepment of disease is concerned.

In growing annual plants one can early notice results and may profit by experience. A few seasons will suffice to determinre about the kind and quantity of fertiliser necessary for them on a particular soil. In the fertilisation of the orange, however, the matter is not so easily determined; only the observations of a series of years will give results which can be depended upon. An orange grower may fetilise with one element one year and get good results, but this is no evidence that the same element used the next year or year after year will prove beneficial; it may, indeed, in prolonged treatment, lead to deterioration and disease. It is this difficulty in experimenting and drawing correct conclusions that accounts for the present poor understanding of rational methods of manuring the orange.

The orange appears to be very sensitive to methods of treatment and fertilisation, and several of the most serious diseases are either caused or aggravated by errors in these. The present paper is based largely on the experiences of intelligent orange growers and upon such observations as the writer has been able to make in the course of investigations of orange diseases.

FERTILISING FOR GROWTH AND FRUIT.

Primarily the orange grower desires to know how to fertilise so as to stimulate either growth or fruit production. With oranges, as with many other agricultural plants, one may fertilise in such a manner that excessive growth is stimulated at the expense of fruit production. A strong nitrogenous fertiliser results usually in much growth and little fruit. This seems to be particularly true if the ammonia is added in an organic form. While trees are young it is probably well to favour the growth of wood principally, but at an age of seven or eight years from the bud, the tree, if it has grown properly, will have attained sufficient size to begin to produce a fair quantity of fruit. It should then be given a slightly modified fertiliser, containing more potash and phosphoric acid and less nitrogen, to stimulate fruit production as much as possible. The so-called chemical manures appear to be much more active in stimulating fruit production than organic manures.

EFFECT ON QUALITY OF FRUIT.

The experience of many orange growers indicates that the quality of the fruit may be largely controlled by fertilisation. As oranges are purchased very largely on their appearance and quality, this becomes an important consideration in manuring. Many intelligent growers are coming to believe that the best results can be obtained by giving the trees an application of that element only which seems to be lacking, and not using, as the majority do, a complete fertiliser, in definite proportions, regardless of whether all the elements are needed by the plant or not. If it can be determined by the appearance of the tree and fruit what element is lacking, this would seem to be the most rational way to fertilise.

It seems reasonable to suppose that by careful study pathological characters induced by starvation might be found, which would serve to indicate clearly the lack of any particular element. Some growers claim to be able to recognize these characters now, and are fertilizing largely on this modified plan, taking advantage of what we might call the sign language of the tree. Some of these characters will be mentioned below under the consideration of the different elements used

EFFECT ON SOIL MOISTURE.

In fertilisation at least two factors must usually be considered, the element of plant food supplied and the effect of this upon the soil as aiding it in supplying the plant with moisture. The heavy application, in late fall or early spring, of an organic manure, like blood and bone, which is extensively used in Florida, is liable to lead to injurious effects during the spring drought, if the trees are on high and dry land On the other hand, such soils might be ameliorated by using substances which attract water and increase the surface tension of soil moisture. Nitrogen, for instance, used in the form of nitrate of soda, and potash, in the form of kainit, would tend to draw up the subsoil moisture and probably aid largely in supplying the necessary moisture during this trying season. The use of organic manures, on the contrary, would only exaggerate the damage produced by drought. If groves are on very moist land, as is frequently the case in Florida, where the necessity is to lessen the moisture rather than to increase it, some form of organic manure, as muck or blood and bone, might be found of benefit.

EFFECT OF FERTILISERS ON THE ORANGE IN HEALTH.

The elements which need to be supplied in fertilisation to most Florida orange groves are nitrogen, potassium, and phosphorous; or using the terms in which they are expressed in most analyses of fertilisers, ammonia, potash, and phosphoric acid. The application of lime would also prove of benefit to many groves. Probably no element of plant food used in the fertilisation of orange groves should be more carefully considered, with respect both to form and quantity, than nitrogen. It is the most costly and at the same time the most dangerous element to use, as excessive applications are liable to resist in extensive dropping and splitting of the fruit or in the production of the serious diseases known as die-back, which will be discussed below.

EFFECT OF NITROGEN.

A Grower may with considerable certainty determine by the appearance of his trees the condition of his grove in respect to the supply of nitrogen available in the soil. An abundance of nitrogen is indicated by a dark green colour of the foliage and rank growth. The fruit shows the effect of an abundance of nitrogen by being, in general, large, with a thick and comparatively rough rind. If the trees have a yellowish foliage, with comparatively small leaves, and show little or no growth, there is probably a lack of nitrogen. In this case there is but little fruit formed, and that formed is small and usually colours early. If the tree is starving from a lack of nitrogen, the foliage will become very light yellow and sparse, and the small limbs will die, as will also the large limbs in extreme cases. If the starvation is continued, no fertiliser being added, the tree will finally die back nearly to the ground and probably die out entirely. The extreme symptoms of general starvation from lack of elements are probably nearly the same. The nitrogen used in fertilisation is commonly derived from mineral or organic sources. Of the former, sulphate of ammonia and nitrate of soda are the forms most used; of the latter, muck, dried blood, blood and bone, cotton-seed meal, tankage, fish scrap, stable manure, etc., are the forms most commonly employed.

INJURIOUS ACTION OF MUCK.

Muck is very commonly applied in considerable quantities either in a raw state or composted with sulphate of potash, etc. Many growers rather fanatically hold to what they term natural fertilisation. By this is usually meant giving the tree nourishment in the form in which they suppose it to be derived in nature. It is contended by many that muck is principally decaying vegetable matter, and that as this is the form of nourishment which the trees obtain in nature, it must be a good fertiliser to use in cultivation. But it must be borne in mind that orange trees as we cultivate them are decidedly not in a state of nature, except that by the cultivation of centuries we have made cultivation and manuring natural conditions which the plant demands. Trees in nature bear fruits for seed to reproduce the species; on the contrary, we grow fruits for market and favour a seedless variety. We want a smooth, thin-skinned, tender, juicy fruit that will sink in water. Nature does not pay particular attention to these characters, so we watch for freaks and sports, abnormal plants, which have the characters we desire, and when found we render these characters permanent by budding. Our aim in

cultivation is not to produce the fruit we find in the wild state, but to modify that fruit to suit our purpose. One of the most efficient methods of accomplishing this is to vary the fertilisation.

While it can not be denied that muck has in some cases given excellent results, it must be conceded that its extensive use has usually been of doubtful benefit and often has done positive injury. Groves which have had liberal dressings of muck are frequently much diseased and produce light crops; the oranges are usually coarse, thick-skinned, and sour; the productiveness is often lessened by extensive premature dropping of the fruit; the tendency seems to be to bring on die-back, a disease which is of frequent occurrence in groves heavily fertilised with muck. What has been said of muck applies to a greater or less extent to the various forms of organic nitrogen used. The tendency of all organic manures rich in nitrogen is to produce a large growth which is weak and sickly. Growth and not fruit is stimulated, and the fruit resulting is usually of poor quality, inclined to be large and rough, with a thick rind and abundant rag.[1]

STABLE MANURE OF DOUBTFUL UTILITY.

Barn manure is largely used by many growers, who still hold to the tradition that chemical manures are injurious to the plants. The benefits of barn manure in an orange grove are in serious question. The fruits produced by nitrogen from this source are, as above stated, usually large, coarse, thick-skinned, with abundant rag, and of inferior flavour. If barn manure is used—and most growers have a limited quantity and desire to use what they have—it should be spread over the grove lightly, so that each tree receives only a small amount. Where such manure is depended upon as the main element of fertilisation, liberal dressings of potash should be occasionally applied; this will tend to correct the evils of an overbalanced nitrogenous fertiliser. What has been said as to the effect of muck and barn manure on the quality of the fruit applies equally to the effects produced by cotton-seed meal, blood and bone, tankage, etc.

In general, organic fertilizers do not stimulate fruiting to the same extent as the mineral fertilizers. It is probably better economy to apply such fertilizers to annual crops, cereals, garden truck, etc.

MINERAL NITROGEN.

The mineral nitrogen manures, nitrate of soda and sulphate of ammonia, apparently stimulate production of fruit more than organic manures and yet promote a fair general growth. The fruit produced by fertilisation with the salts, used in correct proportions with the other elements which it is necessary to apply, is usually of good quality, being solid, juicy, and rich, with thin skin and little rag. Sulphate of ammonia has the effect, growers testify, of sweetening the fruit to a considerable extent. There seems to be little doubt as to the correctness of this view, but why it is so remains in question. The sweetening is probably more marked if there is a slight deficiency of potash. The use of very large quantities of either sulphate of ammonia or nitrate of soda may result disastrously, acting as "chemical poison," killing the trees out-

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1 A term applied to the pithy axis of the orange fruit and the membranes separating the sections.

right and causing them to throw off their leaves. Here again the exact action is not, to my knowledge, understood. The following may be the explanation: It is well known that plants growing on the sea-coast, in soil saturated with the salty sea water, are, in some respects, under almost the same conditions as in deserts, having great difficulty in obtaining sufficient water, though surrounded by water. The root hairs have difficulty in extracting the water from the strong salty solutions. The plants thus have various devices to prevent excessive evaporation or transpiration of water from the leaves, similar to those developed by desert plants. The injurious effect of the nitrogen salts may in this case be caused by simply producing such a strong solution of the salt in the vicinity of the plant that the roots are not able to absorb the necessary moisture, and thus the plant is compelled to cut off its leaves to prevent the transpiration of the water which can not be replenished by further absorption.

Sulphate of ammonia has been very widely used among orange growers. Nitrate of soda has been but little used thus far, but is apparently growing in favour. Its insecticide and water-attracting properties are probably much greater than those of sulphate of ammonia.

POTASH FERTILISERS.

In fertilizing the orange, potash is most frequently used either in the form of the sulphate or of wood ashes. While sulphate of potash has been most widely used, there is apparently little evidence that it is in any way superior, to other forms. Muriate of potash, containing the equivalent of about 50 per cent of actual potash, the form probably most used in the apple and peach orchards of the North, has been little used in orange groves. Apparently those who have used this form have obtained uniformly good results. Kainit, or German potash salt, which is a crude double salt of magnesium sulphate with calcium chloride, containing the equivalent of from 12 to 14 per cent of actual potash, is a form much used in Northern orchards and is promising for use in orange groves. Its very active effect in increasing the surface tension of the soil moisture and thus attracting water to the trees, might make it an excellent form to add in early spring to aid the plant in withstanding the spring drought, which is so frequently injurious to the orange tree, and sametimes fatal to the fruit crop. Growers not supplied with facilities for irrigation would, undoubtedly find it profitable to consider carefully points of this nature in fertilisation. The noticeable effect of potash on the orange tree appears to be its aid in completing and maturing the wood. Apparently an insufficient amount of potash is shown by an excessive growth of weak, immature wood, which does not harden up as winter approaches and is liable to be injured by frost.

An abundance of potash, in the form of sulphate of potash or tobacco stems, is said by many growers to produce excessively sour fruit. That potash is very necessary in fruit production is shown by the fact that the fruit contains a large percentage of this element. An average of fifteen analyses of different varieties of Florida oranges shows 52.05 per cent to be about the usual amount of potash in the ash of the orange fruit. The ash in these fifteen analyses averaged 0.916 per cent, or less than 1 per cent of the total weight of the fruit.

PHOSPHORIC ACID.

Phosphoric acid, which is a very necessary element of fertilisation on Florida orange lands, is mostly used in the form of dissolved bone-black, acidulated bone or phosphate rock, soft phosphate, raw bone, guano, etc. The immediate effect of phosphoric acid on the orange tree and fruit is little understood. Several intelligent growers claim to be able to recognize the effect of phosphorous starvation by the appearance of the new growth of leaves. If these, when they first push out or while they are still young and tender, present a slightly variegated appearance, mottled with light and dark green, it is claimed that they are suffering from lack of phosphorus, and that if a liberal application of some soluble phosphate is applied this appearance may be checked If this can be shown to be true it will prove a valuable index to the available quantity of phosphoric acid in the soil. A similar appearance, may however, appear in light cases of the so-called "frenching," a disease, or probably more properly a symptom of disease, which is not uncommon. Phosphorous starvation, it is true, may have some effect in inducting this disease.

LIME.

Lime, it is usually supposed, is present in sufficient quantities in most of our soils. It may be questioned, however, whether the common high pine land and scrub land, and indeed much of the flat woods and hammock of the interior of Florida, might not be benefited by dressings of lime. From the superiority of oranges grown on soils which are known to be rich in lime it would seem that this is probably a very desirable and necessary element for the production of superior fruit. The fine, smooth-skinned, and deliciously flavoured Indian and Halifax River oranges, with their characteristic aroma, are grown largely on soils rich in lime from shell mounds and coralline and coquina rock. The oranges produced in the noted Orange Bend Hammock, which are of distinctive quality, with delicate, rich aroma, and thin, smooth rind, are produced on a soil underlaid by a marl rich in lime. Lime soils are in many orange countries considered superior for orange growing. Dr. A. Stutzer, in his work on the Fertilisation of Tropical Cultivated Plants, writes: "The orange and citron fruits desire a deep, porous, dry soil, rich in lime. If sufficient lime is not present the fruit will be thick-skinned and not have a fine aroma." It appears also that the effect of abundant lime is to hasten to some extent the time of ripening. Fruits grown on soils rich in lime appear to colour and become suitable for shipping somewhat earlier than those grown on soils containing but little lime. To secure a good quality of fruit the regular application of lime may be found very desirable in many groves.

FERTILISATION AS AFFECTING DISEASE.

Probably the most common cause of injury to orange trees is a lack of fertilisation, yet it is not frequent for disease to be induced or aggravated by excessive or improper fertilisation. This may, indeed, be of much more importance than we are at present inclined to believe. One of the forms of die-back, a common and destructive disease of the orange, is quite evidently due to errors in fertilisation. In other cases he disease appears to be caused by planting in improper soil.

DIE-BACK.

Die-back manifests itself by a number of striking characters. The foliage becomes very dark green, the vigorous growth remains angular and immature and frequently becomes strongly recurved, and the tips turn up slightly, forming S-shaped curves In the spring trees affected with this disease start out a very vigorous growth, which may continue for several months. Finally a reddish brown resinous substance exudes on the twigs, forming the so called die-back stain, which is very characteristic, and they begin to die back This death of tissues may include the entire new growth or only a portion of it. Under the bark of the young limbs gum pockets form and burst out, causing large, unsightly eruptions on the twigs.

Larger gum pockets frequently form at the nodes, producing large swellings. If a tree is badly affected no fruit is formed; if moderately affected an abundance of fruit sets, but the larger portion of this turns to a lemon-yellow colour before half grown, becomes stained by the characteristic reddish exudations like that occurring on the branches, and prematurely falls. Fruit which hangs on the tree till nearly ripe is large and coarse and is frequently stained. It usually splits and falls before thoroughly ripe. The fruit on a slightly affected tree is very large and coarse, with very thick, rough rind. Much of it is rendered unsalable by the reddish die-back stain. It is very prone to split and fall before mature.

Frenching, or variegation of the foliage, frequently accompanies die-back and seems to be a symptom of the disease. The very dark green colouration which some growers believe to be an indication of a healthy grove, may, on the contrary, denote a condition verging on die-back. A lighter green would probably indicate better general health.

DIE-BACK A DISEASE OF INDIGESTION.

Die-back appears to be a form of indigestion, due to an overfed condition of the plant. It occurs apparently wherever excessive quantities of nitrogenous manures from organic sources are applied or become available to the plant. Trees near closets or barns or in barnyards almost invariably have die-back. When chickens roost on a tree for any length of time, so that the droppings fall on the soil beneath, the disease usually results. Many cases are known to the writer where it has apparently been caused by excessive applications of cotton-seed meal, blood and bone, barn manure, etc. Indeed, all organic manures in excessive quantities appear to give rise to it. If organic fertilizers are used they must therefore be applied with considerable caution to avoid an excess. No safe rule can be given as to the amount of manure that can be used with safety; this depends upon the size and condition of the tree, previous treatment, and soil conditions.

Whether the chemical manures, nitrate of soda and sulphate of ammonia, will produce the disease if used in excessive quantities, is questionable. We have not been able to learn of any instance where this has occurred. Several cases are known where nitrate of soda was used of sufficient strength to cause the leaves to fall without producing any sign of this disease. Frequently the method of cultivation has considerable to do in causing die-back, excessive cultivation appearing to aggravate it very greatly.

MAL-DI-GOMMA.

The much-dreaded disease of foot rot, or mal-di-gomma, is probably not produced primarily by improper methods of fertilisation, but seems to be considerably affected by the use of fertilisers and methods of cultivation. Groves in which cow-penning* has been practiced to a considerable extent are frequently affected with foot rot. This is so generally the case as to admit little doubt that this practice has considerable to do in inducing the disease. The extensive application of organic manures appears also to aggravate the malady to some extent, and their use in infected groves should be discouraged.

INSECT DISEASES.

With regard to the effect of fertilisation upon insects which infests the orange, it may be said that the question is little understood. A general impression exists among the growers of the State that groves fertilised with blood and bone or barn manure are more liable to be badly infested with injurious insects than those fertilised exclusively with chemical manures. This appears to be especially true in the case of the six-spotted mite (*Tetranychus 6-maculatus*) and the purple scale (*Mytilaspis citricola*); judging from observations on many groves which have been fertilised with chemical manures only, it certainly seems that this belief is well founded. There is some evidence that the muriate of potash aids to some extent in preventing the ravages of the rust mite. Dr. Smith of the New Jersey Agricultural Experiment Station, has found nitrate of soda and kainit to be very active insecticidal fertilisers. These have not been used to any extent in fertilising orange groves in Florida, and no data have been obtained as to their effect on orange insects. It is probable that they would prove more effective than sulphate of ammonia or sulphate and muriate of potash, and they should be thoroughly tested to determine their value as fertilisers for the orange.

SUMMARY.

Summarising, it may be said:

(1) By a proper combination of the various elements used in fertilisation one can undoubtedly largely govern the quality and flavour of the fruit.

(2) To obtain a fruit with thin rind, use nitrogen from inorganic sources in moderate quantities, with considerable potash and lime.

(3) To sweeten the fruit, use sulphate of ammonia in considerable abundance, decreasing the amount of potash.

(4) To render the fruit more acid, increase the amount of potash and use nitrogen from organic sources.

(5) If it is desired to increase the size of the fruit, as is sometimes the case, apply a comparatively heavy dressing of nitrogen in some organic form and slightly decrease the other elements. In the case of the tangerine and mandarin, where a larger size is usually desired, a heavy dressing of nitrogen fertilisers would favour this end, and is not objectionable unless carried to excess.

(6) Fertilisation has an important bearing on diseases.

(7) Die-back, a serious malady, is in all probability the result of over-feeding with nitrogenous manures from organic sources. These manures if used at all should be applied with great caution.

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* A term used to designate the practice of penning cattle in orange groves over night, using a movable pen, the position of which is changed every few days.

(8) Foot rot, although not primarily due to improper methods of fertilisation, is no doubt considerably influenced by this cause.

(9) Insect diseases are also apparently influenced by the use of fertilisers, organic manures rendering the trees more liable to injury from this source than chemical fertilisers.

MANURES AND COFFEE.

SIR JOHN LAWES ON THE MANURING OF PLANTS.

The great English agricultural authority, Sir John Lawes, in answer to some queries of ours regarding the manuring of coffee and tea, has given expression to opinions that will go far to convince the old style of planters of the correctness of their long-established contempt of chemical manure.

This is what he says:—

"Our investigations leave very little doubt in regard to the proper manure for plants of the Graminaceous order, such as wheat, barley, oats, maize, &c. That is to say, plants which ripen their seeds in the course of a few months require their food in the most active condition; and by means of salts of ammonia, or nitrate of soda combined with phosphates, we have grown continuous crops of wheat and barley for more than half a century without change. The same substances will produce sugar in the root crops such as mangolds, turnips, sugar beet, &c. These manures do not give the same results when applied to plants of the leguminous order, and we have still a great deal which is quite unexplained in regard to the method by which these plants derive their food, as is the case with the crops named above. We cannot grow our leguminous crop continuously. Referring now to the subject of your letter, I should say most decidedly that the active artificial manures would not be suitable for the coffee tree, and I should be much more disposed to trust to the indirect action of some leguminous plant. I have not much faith in the loppings and leaves of leguminous trees. I have several growing Acacias in my pasture, and I could never see that the grass was better under them. I should select any annual leguminous plant, pea, bean, or any one which grows most luxuriantly in the district, and dig or plough them under the soil when they are most luxuriant. These leguminous plants do not flourish well except in a soil where there is plenty of lime and potash. I have a letter before me from a gentleman in the Mauritius where they grow d'acharia beans to plough in as a manure for the sugarcane. He sends me a sample of coral sand which he says has a wonderful effect upon the beans when used with lime, when lime alone will not act. It is the potash in the sand which acts as a manure for the bean, and it is the nitrogen which the beans collect, partly from the atmosphere and partly from the subsoil, which manures the cane. Should you feel inclined to try the effect of direct manures, I should use very finely ground bone dust either alone or mixed with rape or other cake, or dried blood. But avoid nitrates, salts of ammonia, and if you use phosphates, employ basic slag in preference to superphosphate."

The chief point of the above letter is without doubt the strong distrust of evanescent chemicals as manures for perennials, such as coffee or tea. The next in importance is the recognition of the value of leguminous plants, though perhaps Mr. Nelson may feel sore at the

implied doubt on his "Rêve d'Or" system, a system, however, which bids fair to effect a revolution in estate manuring in India at least, Referring again to chemicals—this term must not be, as it so often is. confused with organic "artificials"—our numerous manure factories should indent for a supply of basic slag, which at home and on the Continent is fast acquring a great reputation as a permanent manure. —*Planting Opinion.*

REPORTS ON SUGAR-CANES.

By Arthur J. Webb.

Llandovery Estate, St. Ann.

Name of Cane.	Gallons Juice per Acre.	Density. Arnaboldi.	Weight Cane per Acre.	Weight Tops per Acre.	Percentage of Juice.	Remarks.
			tns. c. q.	tns. c. q.		
No. 115 ...	4,961	26°	37 15 1	10 16 0	5·85	Arrowed partially.
87 ...	3,690	26°	28 11 3	8 14 1	5·86	" heavily.
69 ...	1,690	27°	14 1 0	7 3 2	5·38	No arrow.
275 ...	2,541	25°	27 4 2	6 6 1	4·10	Few arrows.
269 —	3,751	25°	32 12 1	9 14 2	5·13	No arrow.
116 ...	3,751	25°	28 6 0	9 14 2	5·91	Arrowed partially.
102 ..	4,356	25°	31 2 1	8 12 3	6·25	No arrow.
74 ...	3,267	26°	24 8 1	7 15 2	5·97	do.
99 ...	3,267	26°	25 0 2	7 6 1	5·62	Very heavy arrow.
Caledonian Queen	1,754	24°	16 12 0	6 6 1	4·82	No arrow.
Norman ...	2,420	24°	20 6 0	7 7 3	5·32	do.
Bouranappa ...	1,452	26°	11 13 1	6 1 0	5.55	do.
Ropoappa ...	3,388	24°	25 1 1	8 12 3	6·20	do. but lodged badly.
China ...	3,872	27°	28 7 0	7 11 1	6·01	Heavy arrow & lodged badly.
Hilli ...	1,573	25°	13 16 2	7 3 2	5·07	No arrow.
All the above canes were planted on 4th Feby., 1896, and cut on 20th Feb., 1897.						
No. 81 ...	3,388	22°	28 10 1	14 9 2	5·30	No arrow.
This Cane was planted on 29th March, 1896, and cut on 20th Feby., 1897, and was not ripe at the time of cutting.						
Black and Transparent	3,872	26°	32 8 1	7 5 2	5·53	Partly arrowed.
These are the ordinary canes in cultivation on the estate planted and cut under similar conditions.						

Remarks.

All the tops were planted in well-forked cane holes of 4½ feet banks—the tops being planted 3 ft. apart. The land was well manured with stable dung and irrigated until 5th May when they took the bank. The situation is about 40 feet above sea level and is much exposed to the strong sea breeze and "Northers." There were two fine ripening months before the date of cutting.

The great difference of the weight of cane per acre is perhaps due to the tops received from the gardens, some varieties being much better than others.

A good ratooning cane is essential for cultivation on the estates in this part of the Parish of St. Ann, and it remains to be seen which of the varieties will best stand the test of ratooning. I am inclined to think that Nos. 116 and 102 will turn out the best—they appear to be hardy and have a large percentage of juice. It is worth noticing that the old canes, now being cultivated on the property and which are excellent ratooners, compare very favourably as plants with the best of the "new comers."

Rainfall from 4th Feby., 1896, to 20th Feby., 1897, 58·34 inches.

Grown by Capt. L. Shirley.

Etingdon.

No.	No. of Roots.	No. of Canes.	Weight of Canes.	Weight of Trash.	Galls. Juice.	Density of Liquor.	—
			lbs.	lbs.			
95 ...	50	323	457	152	22	27	60 o/o
74 ...	50	245	331	126	17	21	62 o/o
115 ...	50	318	880	371	48	22	58 o/o
Cal. Queen...	24	116	200	60	10	22	70 o/o

Hyde Hall.

Cane—No. 95.

Weight of Cane	...	300 lbs.
Weight of Trash	...	89 lbs.
Density of Liquor	...	27.

Cane—No. 74.

Weight of Cane	...	300 lbs.
Weight of Trash	...	90 lbs.
Density of Liquor	...	27.

Cane—No. 115.

Weight of Cane	...	300 lbs.
Weight of Trash	...	98 lbs.
Density of Liquor	...	29.

Cane—"Caledonian Queen."

Weight of Cane	...	236 lbs.
Weight of Trash	...	60 lbs.
Density of Liquor	...	26.

SOIL FERMENTS IMPORTANT IN AGRICULTURE.

By Dr. W. H. Wiley, Chief of the Division of Chemistry, U. S. Department of Agriculture, in *Year Book of U. S. Dept. of Agriculture for 1895.*

(Continued).

PRECAUTIONS IN SAMPLING.

First of all, the method of sampling must be such as to secure for examination portions of soil which certainly contain no other organisms than those locally found therein. The methods of securing the samples are purely technical, and will be fully described in a special bulletin from the Division of Chemistry of the Department of Agriculture.

THE CULTURE SOLUTION.

Many readers of these pages who are not bacteriologists will be interested in knowing the character of the solution which is used for testing the nitrifying vitality of the ferments in the soil. A solution which we have found very useful for this purpose is composed of the following constituents; Potassium phosphate, one gram; magnesium sulphate, half a gram; ammonium sulphate, two-tenth gram; calcium chloride, a trace, and calcium carbonate in excess of the amount which will be necessary to combine with all the nitric acid produced from the ammonium sulphate present. The above quantities of materials are dissolved or suspended in one litre (about one quart) of water, and one-tenth of this volume is used for each culture solution. This quantity is placed in an Erlenmeyer flask, which is then sterilised, after stoppering with cotton, by being kept at the temperature of boiling water for an hour on three successive days. The flask itself before using, should be thoronghly sterilised by heating to 300 deg. F. for an hour.

The calcium carbonate employed in the above culture solution should not be prepared by finely grinding marble or chalk, but in a chemical way by precipitation. It is best thoroughly sterilised separately and then added to the flask immediately before seeding. The sterilized spoon which is used for seeding, holds, approximately, half a gram of the soil. This spoon is filled from the contents of one of the freshly opened sample tubes, underneath a glass hood, the plug of cotton is lifted from the sterilized flask, and the contents of the spoon quickly introduced and the plug of cotton replaced. While the above details are well known to the bacteriologist, they are not appreciated, as a rule, by the general reader. From the numerous inquiries concerning this process which have been received at the department, it is believed that the above brief outline of the method of procedure of securing samples of soil and seeding sterilized solutions therewith will be useful.

NOTING THE PROGRESS OF NITRIFICATION.

It will be seen from the above description that the object of the tests in question is to determine the activity and strength of the nitrous and nitric organisms alone, inasmuch as the process begins with an ammoniacal salt. At the end of five days from the time of the first seeding, a portion of the solution is withdrawn in a sterilized pipette for the purpose of determining whether or not the process of nitrification has commenced; and if so, to what extent it has proceeded. This may be accomplished by either determining whether any ammonia has been destroyed

or whether any nitrous or nitric acids have been produced. These processes are of a purely chemical, technical nature, and therefore would not be properly described in this place In the case of an active and fertile soil, the nitrifying process begins promptly, and, as a rule, continues with unabated vigour until the whole of the nitrogen present in the ammonium salt is converted into nitric acid. In very favourable circumstances this object will be accomplished in about six weeks. When the organisms in the sample are few in number or deficient in vitality, the nitrification does not begin for a long time, and then goes on with great slowness. By tracing the progress of the fermentation, as described above, it is seen how easy it is to compare various samples of soils in respect of nitrifying power. If after four or five weeks no trace of nitrification has been found, the soils are regarded as being practically deficient in nitrifying ferments. This often happens with samples taken at a depth of three or more feet, or even in the case of surface soils or others subjected to conditions inimical to fermentative life.

REPRESENTATION OF THE DATA OBTAINED.

In the actual work which has been done in this department to follow the progress of nitrification in culture solutions it has been found convenient to determine the rate of the fermentative change by the determination of the nitrous and nitric acids produced. It is evident that in the process of fermentation three cases may arise. In the first place, the nitrous fermentation may occur first, and after its completion the nitric may follow it. This is a condition which evidently would rarely arise, and could only occur when the nitrous ferment was present in such a predominating quantity as to subdue and restrain vitality of the nitric ferment In the second place, the two fermentations could go on synchronously, and in this case the solution when tested would never contain more than the merest trace of nitrous acid. This condition of affairs would only occur when the two ferments were present in about equal numbers and endowed with equal vitality. In the third place and this is the one which commonly occurs the two fermentations go on synchronously, but at first the nitrous fermentation is more vigorous, so that there may be a considerable accumulation of nitrous acid in the solution. After a few weeks the nitric fermentation begins to gain in vitality by reason of the fact that the raw material on which the nitrous ferment worked has become nearly exhausted. The quantity of nitrous acid, therefore, which was at first formed would gradually begin to disappear, and finally, if the examination be continued long enough, be reduced to zero at or before the time when the total amount of nitrogen present would be converted into nitric acid.

In order to represent the progress of the fermentation, it has been found most convenient to use a graphic form of illustration. The method of doing this is illustrated in a chart showing the progress of nitrification in a sample of soil taken a depth of 15 inches below the surface, on the 27th of April, 1895, at the Canebrake station in Alabama. The culture solution was seeded with a sample of this soil on the 3rd of May, and the progress of nitrification is represented in the chart. The figures in the perpendicular column on the left represents the parts per million of nitrous or nitric acid. The continuous line represents the sum of the nitrous and nitric acids. The dotted line represents the

nitrous acid in the solution. At any given time the actual amount of nitric acid present can be found by taking the difference between the continuous and dotted lines. Thus, at the end of the fifth week it is seen that there were nearly four parts of nitric acid present per million The diagram shows that no action took place during the first two weeks after seeding. During the third week there was a vigorous evolution of nitrous acid, with only a trace of nitric rcid During the fourth week, attending a depression of temperature, the bacterial action was less active. During the fifth week both the nitrous and nitric organisms were active, attending a considerable rise of temperature. After the fifth week, the nitrous acid began rapidly to disappear, being converted into nitric acid. The horizontal position, however, of the continuous line shows that no additional nitrons acid was formed from the ammonia during the sixth week. During the seventh week there was no activity either of the nitrous or the nitric ferment. During the eight and ninth weeks both ferments were again active, the nitrous acid being converted into nitric acid as soon as formed.

The second diagram gives the variations in temperature of the closet where nitrification took place during the whole time of observation. The upper line represents the maximum and the lower the minimum temperatures at the time mentioned. It will be seen by comparing the two diagrams that there is in general quite a marked agreement between the rate of nitrification and the degree of temperature This is shown by the slow rate of nitrification during the third and fourth weeks and the rapid rate during the fifth week.

It is evident that many conditions beyond the control of the operator may serve to render the observations upon the rate of nitrification somewhat unreliable, but in general the data of nitrification properly ascertained will give an unerring insight into the character of a soil as affecting its ability to furnish nitrogen to the growing plant, and hence to that extent to the degree of its fertility.

PREPARATION OF PURE CULTURES.

It is evident from an inspection of the processes mentioned above that the ferments which are obtained in the culture solution are not confined to the nitrous and nitric organisms. All the ferments which the sample of soil may have contained of every description suited to grow in the culture solution employed will be developed. The solution, therefore, after the nitrification is complete, contains not only the nitrous and nitric micro-organisms, but also all the other bacteria contained in the original sample capable of growing in the environment provided. It is probable that in different parts of the country and at different latitudes the species of nitrifying ferment may vary, and, therefore, it is of great importance to continue the examination of these bacteria until pure cultures are obtained. The methods of securing these are so technical and of so purely a bacteriological nature as to exclude them from description here. It will be sufficient to say that these pure cultures are obtained by seeding new cultures directly from the solutions obtained in the nitrifications produced by the soils as described. This work is continued until all the disturbing bacteria are eliminated, and there are left only those which will produce under favourable circumstances the nitrous and nitric fermentations alone.

SUMMARY.

1. Conclusions which are easily derived from the above data are that the soil is not merely dead, inert matter, but, on the contrary, in the highest degree a living organism. It contains numerous ferments which in their activity either favour or restrain the growth of crops. It is the part of scientific agriculture to determine, in so far as possible, the laws which govern the evolution of both of these forms of bacteria for the purpose of securing the greatest activity of the beneficial organisms and the least activity of the inimical ones.

2. The bacteria which provide niirogenous food for plants are of three great classes. One of these exerts its activity only on organic nitrogen contained in the humus of the soil. The second class is developed symbiotically with the growing plants, herding in colonies upon their rootlets, and securing in their vital activity an oxidation of the free nitrogen of the atmosphere. The third class of organism and the one least known appears to have the ability, in an independent form of life and without the aid of plant vitality, to secure the oxidation of atmospheric nitrogen. The first of the classes mentioned above is itself separated into three divisions comprising the organisms which produce ammonia, nitrous and nitric acids, respectively.

3. Many crops, such as the cereal, have no ability in themselves to increase the stores of nitrogen in the soil. Such crops may be grown for many years upon the same field, in which case the nitrogenous supply of the field will at first be rapidly diminished, with a corresponding decrease in the crop itself. Finally a time will come when a certain minimun crop will be produced apparently for an indefinite time, varying only under seasonal influences.

4. Other plants especially leguminous plants, favour the development of the organisms which are capable of oxidising free nitrogen and thereby tend to increase the supply of available nitrogenous matter. These crops, however, together with certain root crops, cannot be grown successfully without rotation, and all crops are benefited by a judicious succession.

5. The summer fallowing of land is highly injudicious, and especially if the field be left bare through the winter The nitrates which are formed by the activity of the nitrifying organism in such cases are easily washed out by heavy rains and lost to agricultural uses perhaps for thousands of years.

6. Late autumnal ploughing, after the activity of the nitrifying organisms has practically ceased, may prove beneficial, especially to some crops, by exposing the soil to the decomposing effects of the frosts of winter.

7. In past geological ages vast quantities of nitrogenous matters have been oxidised and stored, in the form of nitrates, and these stores are now available for the uses of agriculture.

Nitric acid, in the form of nitrates, should be employed only as a temporary fertiliser in order to improve the fertility of the soil to such an extent as to make profitable the growing leguminons crops. The continued use of nitrates for fertilising purposes deprives the nitrifying organism of their functional activity, and hence tends to diminish the numbers and to enfeeble their work. Nitrates should only be applied in small quantities at a time, sufficient to meet the demands of the crop. It is better to apply the dressing of nitrates at two or three different times during the growth of the crop, rather than to use it all at once.

8. The use of sewage for fertilizing purposes is not to be commended, because of the danger of contaminating the soil with pathogenic ferments which may subsequently infect the health of man and beast. These ferments may attach themselves to plants and thus ener the animal organism, or they may remain with a suspended vitality for an indefinite period in the soil and awaken to pernicious activity when a favourable environment is secured.

9. The study of the nitrifying organisms in the soil and their culture and isolation will in the end prove of great benefit to practical agriculture by showing the method in which favouring organisms can be fostered and the activity of the inimical organisms reduced to a minimum.

NOTES ON PLANTS IN CASTLETON GARDENS.

PTEROSPERMUM ACERIFOLIUM, Willd.—A tall tree found in the sub-Himalayan tract as far east as Burma. The down on the leaves is used by the hill-people in Sikkim to stop bleeding in wounds. In the Konkan the flowers and bark, charred and mixed with Kamala powder, are applied in suppurating small-pox. In Bombay and Bengal the leaves are employed as plates, and for packing tobacco. The flowers are used by Bengalis as a disinfectant and to keep insects away from bed-clothes, etc.; they are also said to render water gelatinous.

The wood is occasionally used for planking in Bengal, and it is said to take a fine polish, and to be suitable, for making furniture.

Other species from India growing in the Gardens are Pterospermum lancæfolium and P. Heyneanum, *(Sterculiaceæ).*

GARCINIA INDICA, Chois.—A slender tree with drooping branches, found on the Ghats of the Konkan and Kandra. It bears a conspicuous spherical purple fruit, the size of a small orange, which ripens about April.

Oil.—A valuable oil called "Cocum" or "Kokam butter," "Mangosteen oil," or "Brindonia tallow," is obtained from the seeds of the fruit to the extent of about 30 per cent. Kokan butter has been employed by the natives, of at least south-western India, since remote times, but it does not appear to have attracted the notice of Europeans till about the year 1830. It is considered demulcent, nutrient, and emollient. One writer states, "I have used it internally in my practice, and have found that its best medicinal properties are its usefulness in phthisis pulmonalis and some scrofulous diseases, and in dysentry and mucous diarrhœa."

The purple fruit has an agreeable flavour, and has long been esteemed as an article of diet.—(*Guttiferæ*).

MIMUSOPS ELENGI Linn.—An evergreen tree, frequently cultivated in India, wild in the Deccan and Malay Peninsulas. It is cultivated for its ornamental appearance, and its fragrant flowers. The latter are valued for making garlands, are sometimes used for stuffing pillows and the atter distilled from them is esteemed as a perfume. From the seeds a fixed oil is obtained by expression, which is used for culinary purposes, for burning and for medicine.

The wood is close and even-grained, pinkish to reddish-brown in colour, and takes a good polish. It is used in house-building, for cart shafts and cabinet work, and is said to last for fifty years.—(*Sapotaceæ*).

AVERRHOA CARAMBOLA, Linn.—The Carambola of the East Indies

is a small tree with leaflets which are slightly sensitive. It produces an abudance of prettily shaped five-angled yellow fruits. The fruits are acid, but make an agreable preserve, and are also used for making pickles and curries; the juice removes iron-mould from linen. The dried fruit is given in fevers, and is also an antiscorbutic.

A correspondent sends the following recipe for Carambola preserve :—

Four tablespoonfuls of refined sugar to one doz. of the fruit. Peel the fruit and put them together with the sugar in a covered stewpan, without any water, on a slow fire. After a few minutes uncover the pan and skim the fr th frequently. In about fifty minutes they will be done, and ought to be of a bright amber colour. As a Tart, simply cut across, and bake with crust.—(*Geraniaceæ*).

STIFFTIA CHRYSANTHA.—This is a handsome Brazilian shrub.

It has lanceolate-acuminate leaves, and terminal heads of showy orange-coloured flowers, issuing from amongst the long, coloured pappus-hairs. The flowers somewhat resemble a painter's brush in shape.—(*Compositæ*).

GRASS-FIRING.

By MR. F. TURNER, F.L.S., in *Australian Grasses.*

I have been often asked whether I favour the annual burning off of grasses. Except in three cases, I am decidedly against burning off, for the following reasons:—1. It destroys millions of grass seeds which occasional good seasons may have brought to maturity, thereby destroying the only natural means for the reproduction of the grasses. A fire also destroys many valuable salsolaceous and other plants. 2. After burning off, if favourable weather ensues, new growth is made qnickly, and sheep turned into such pasturage eat greedily of it, which often gives them what is commonly termed the scours or diarrhœa, which sometimes become chronic, and of course has such a weakening effect upon them that many die. Nor is this all, for in biting out the young growth from the heart of the grass, much of the latter is often brought with it, which of course partially destroys it. If a fire should take place, sheep should never be turned into the pasture until it has made considerable growth, though cattle may be turned in without any serious damage being done, for they never eat grasses so low as sheep. I may here mention the fact that sheep destroy the natural grasses and herbage in much less time than horses, and the latter much sooner than cattle.

I am in favour of burning off annually under such conditions as the following:—(1st) Where grasses and other herbage are much diseased with parasitic fungi; (2nd) where there is a predominance of 'spear,' 'corkscrew,' 'wire' (*stipa*), and 'three-armed spear' grasses (*aristida*); and (3rd) where rank growing grasses are abundant, which is generally on wet or undrained land, for along with this coarse growth many noxious plants and fungoid pests are destroyed (very rarely good pasture plants, other than grasses, will grow in such situations). Pasturage treated in this way becomes more healthy, the fire acting as a disinfectant, and contagious diseases disappear. Grasses that grow in low, damp situations are often a valuable stand-by for stock during protracted droughts.

RULES AS TO SALE OF LANDS BY THE GOVERNMENT OF JAMAICA TO SMALL SETTLERS.

(AMENDED.)

1. No more than 50 acres will be granted to one purchaser, nor less than 5 acres.

2. The price at which the lands will be sold may be learnt at the Office of the Surveyor General, or from the Bailiffs in charge of the different parcels. The ruling price will be the same as that at which lands in the neighbourhood are put in the market.

3. The Surveyor General on receipt by him of an application in the form endorsed hereon and on deposit of one-fifth of the price of the lands shall cause a survey to be made of the quantity of land applied for, the applicant receiving notice of the time when the survey is to be made.

4. On the survey being made the applicant shall forthwith be entitled to possession of the land allotted to him on such survey.

5. If the applicant shall be dissatisfied with the situation, or configuration of the land allotted to him on such survey, and shall within one week after the survey, give written notice thereof to the Surveyor General or to the Surveyor who made the survey, or to the Bailiff in charge of the land, and shall deliver up possession of the land, he shall be entitled to a refund of one-half of the amount deposited by him as above and his application shall be deemed to be withdrawn.

6. If such notice shall not be given, or possession delivered, the applicant shall at the end of one week after the survey be deemed to be the purchaser of and to be in possession of the land allotted to him on such survey, and as soon thereafter as practicable a certificate shall be delivered to him by the Surveyor General, who shall keep a duplicate of such certificate in his office.

7. Such certificate shall be in the form following :—

SALE OF GOVERNMENT LANDS TO SMALL SETTLERS.

Jamaica s.s. Office of Surveyor General, Kingston.

This is to certify that of the Parish of Yeoman (hereinafter called the purchaser) did on the day of 189 , pay the sum of £ , being one-fifth of the purchase money of £ , in respect of acres of land part of in the Parish of , and that the situation and configuration of the said acres are as shown by survey thereof made by on the day of 189 , which can be seen on application at the Office of the Surveyor General in Kingston.

The land comprised in this certificate is held subject to the following conditions :—

(1.)—The remaining four-fifths of the purchase money and £2 being the cost of survey, together amounting to £ , are payable in ten years by ten equal yearly instalments of £ , each without interest, the first of such instalments being payable on the day of 189 , and the subsequent instalments at intervals of one year thereafter. Provided that if within such period of ten years the purchaser shall have brought one-fifth of his acreage into good bearing in Kola, Coffee, Oranges, or other permanent crop-producing

plants, he shall be released from payment of, or be refunded as the case may require, one-fifth of the purchase money.

(2)—Such paym-nts shall be made to the Collector of Taxes for the said Parish of , and the receipt for each payment must be endorsed on this certificate which must be produced to the Collector of Taxes at the time of payment.

(3)—The balance of the purchase money and costs of survey may however be paid in advanc at any time and the Collector of Taxes is authorised to receive such payments whenever tendered

(4)—If the purchaser shall at any time be six months in arrear in respect of payment of any yearly instalment on account of purchase money and costs of survey, the Surveyor General on behalf of the Government may give a notice calling on the purchaser or person in possession to pay the arrears due.

(5)—Such notice shall be served either by being delivered to the purchaser or person in possession of the land, or by being affixed to some tree, or posted on some other conspicuous part of the land.

(6)—If at the expiration of one month from the service of such notice the requirements of same have not been complied with, the Surveyor General may by himself, or some person appointed by him, enter into possession of the land and may either before or after such entry sell the same at public auction or private contract as he may deem fit and either on conditions similar to those contained in this certificate or otherwise. The proceeds of such sale after payment of all expenses shall be applied in paying to the Government the balance of purchase money and costs of survey remaining unpaid at the time of such sale, whether the same shall be in arrear or not, any surplus when realised being payable to the purchaser or other person entitled thereto.

(7)—On payment of the purchase money and costs of survey in full the purchaser or other person entitled thereto will receive from the Crown a conveyance or patent in fee simple in the usual form and with the usual reservations, including a reservation to the Government of the right to make new roads or improve existing roads, the Government paying the cost of any damage actually done to fruit trees, growing crops and cultivated ground in making or improving such roads.

(8)—No transfer of, or dealing with the rights of the purchaser in the land comprised in this certificate shall be effectual until written notice thereof shall have been given to the Surveyor General duly authenticated to his satisfaction.

Dated this day of 189 .

Surveyor General.

SALE OF GOVERNMENT LANDS TO SETTLERS.

Application.

I, of the Parish of do hereby apply to become the purchaser of acres of land, part of in the Parish of for the sum of £ . And I herewith

deposit with the Surveyor General the sum of £ , being one-fifth of the price of the said land and agree to be bound by and to conform to the within rules in respect of my purchase.

Dated this day of 189 .

COLLECTING JUICE OF PAPAW.

By F. B. Kilmer.

Cut an incision lengthwise of the fruit. The incision not to be over an eight of an inch deep. If it is made much deeper, the milk is apt to be carried into the fruit and not run outside. The milk will run quite freely for a short time, but soon coagulates so that it will no longer run. To catch the milk that drops and flows I place under the tree, tin pans made in such a way as to surround the trunk of the tree and catch the dripping milk.

I found it well to tap the fruit early in the morning before the sun was very high as the sun quickly dries the milk and stops the flow. I found that it was a good practice after the flow had ceased, to brush off all of the coagulated milk into the pans and make a fresh incision, and you would get another but a smaller yield. I make the scorings about one-half inch apart all round the fruit. The time to tap the fruit is before it is ripe and when it is green and full. The yield is much larger just after a rain storm or a spell of wet weather. Still you can tap a green fruit at any time and get more or less of the white milk.

This milk must be dried the same day that it comes from the tree and *must* be dried in the sun. Artificial heat will not do. It can be dried right away on the tin pans spread out thin, or spread out on sheets of glass. It will dry in an hour or so in the sun. Any amount of exposure in the sun will not harm it in drying, but artificial heat destroys it. If it should so be in gathering, that owing to stormy weather it cannot be dried in the sun the day it is gathered, you can mix it with some naptha or benzine so-called, turning it into a sort of milk.

FERNS: SYNOPTICAL LIST—XLV.

Synoptical List, with descriptions, of the Ferns and Fern-Allies of Jamaica. By G. S. Jenman, *Superintendent Botanical Garden, Demerara.*

1. *Polypodium Fawcettii*, Baker.—Stipites tufted from a slender upright villose rootstock, $\frac{1}{3}$ rd. of an in. or less l. dark-coloured filiform denselyvillose with spreading brown or reddish hairs; fronds spreading linear-ligulate 2-3$\frac{1}{2}$ in. l. 1$\frac{1}{2}$-2 li. b. bluntish or rounded at the apex, tapering and decurrent at the base, pale, yellowish-green, thin and flaccid, clothed with fine spreading scattered hairs, specially on the midrib and margins, the latter slightly repand; rachid filiform, purplish at the base, enclosed above this; veins fine, curved, not reaching the edge, with a short anterior soriferous branch; round, terminal, contiguous but apart, forming a medial or subcostate row on each side of the midrib.

Infrequent at 4,000-6,000 ft. alt. in damp forests on the trunks and branches of trees; distinguished by the simple, entire, soft-textured

N. B.—The Lists in January and February ought to have been numbered XLIII and XLIV respectively.

fronds, which are often curved laterally falcate-form. It was first discovered in 1875 at Morce's Gap and on the slopes of John Crow Peak, when it was referred to *P. jungermaniodes*, Klotzsch, and again in 1889 when it was named after Mr. Fawcett.

2. *P. dendricolum*, Jenm.—Rootstock very small, erect, finely filamentose scaly; stipites 1–2 li. l., densely tufted, erect, brown, clothed with fine castaneous hair-like scales; fronds simple, linear, erect, 2–3 in. l. 2 li. w. stiff, dark brown-green, underside paler, both surfaces ciliate, the margins shallowly scalloped above the plain narrowed base; midrib on both surfaces covered by parenchyma; veins fine three-branched in each lobule, spreading, the interior foreshortened and fertile at the apex; sori one to each scallop, alternate, round, medial apart, superficial, receptacles embossed, dark sub-oblong. Gard Chron. Oct. 20th 1894.

Apparently very rare, only one plant having been found, on trees at 5,000 ft. alt., in the highest mountain ranges. It differs from the previous species by its erect habit, stiff, thicker texture, scalloped margins and three-branched spreading veins.

3. *P. gramineum*, Swartz.—Rootstock 1–1½ li. thick, short creeping, densely clothed with light brown somewhat squarrose scales; stipites contiguous, several arising near together, slender, puberulous, ¾—1½ in. l., stiff; fronds linear-accuminate 3–5 in. l, 2–2½ li. w., narrowed and cuneate at the base, tapering and often attenuated at the apex usually more or less curved, stiff and subcoriaceous, grass-green, margin at first slightly ciliate, the surfaces otherwise naked and glossy; veins oblique, evident on the upper side, forked, both branches reaching the marginal thread; rachis filiform, covered; sori oval, rather large, medial on the superior vein branch, sub-parallel with the margin.—*Grammitis*, Sw.

Common on trees, often in large patches, from 4,000 ft. alt. upwards; marked from its allies, by the horizontal growth of the rootstock, narrower, grass-like, fronds, with distinct petioles, medial sori, veins excurrent to the marginal thread, which, with both veins and midrib, is covered by the parenchyma.

4. *P. nigro-limbatum*, Jenm.—Rootstock small, fibrous, upright or oblique, densely clothed with fine subulate castaneous scales, the roots densely hairy; stipites wiry, short, dark brown; fronds erect, stiff, coriaceous, acute or acuminate, long attenuated to the base, 4-10 in. l. 1½-3 li. w. naked, glossy, green, the plain or repand margin edged with a black glossy thread; veins close, simple, straight, oblique, clavate, not reaching the margin, the fertile with a spur near the anterior base causing a slight decurvative of the outer two-thirds, both veins and midribs covered by membrane; sori oval, rather oblique, close forming a double costal series in the upper part of the frond, but rarely reaching the top. *Grammitis nigro-limbata*, Spruce, Ms. *G. nimbata*, Fée.

Frequent on the upper boughs of trees in damp forest along the higher ridges and peaks from 5,000 or 6,000 ft. alt., alone in places, in places, or scattered with the following and nearly as common. The glabrous surface and taper-pointed fronds readily reveal its individuality without the examination of other characters. It has a very wide Andean range in South America.

5. *P. marginellum*, Swartz.—Rootstock slender, elongated, erect,

densely clothed with loose subulate brown scales; stipites tufted, stellate-ciliate, under ½ in. l., black, winged by the decurrent sides; fronds spreading, 2-4 in. l. 3-4 li. w., ligulate, gradually tapering at the base, the apex obtuse, rounded, as wide or wider there than below, or sometimes narrower; firm but not coriaceous, ciliate, especially on the distinct black marginal thread, which in time separates from the membrane; rachis covered; veins immersed, once or twice forked, the inferior branch curved, and sometimes prolonged to join near the margin the next inferior one above it, thus forming distinct areolœ that enclose the sori, more often however free not reaching the margin; sori oval, rather large, dark brown, oblique, situated on the shorter superior veinlet or spur near the midrib. *Grammitis*, Sw.

Common on the upper branches of trees in forest at 5,000-7,000 ft. alt.; marked from the previous species by the different shape of frond, form of the venation and presence of vestiture. In both the marginal thread is black and glossy, and not covered by the parenchyma as in *gramineum*, separating eventually as the fronds decay, the veins not entering it. Casually the branches of the same vein meet and form a narrow mesh. I have not seen specimens of this from the mainland, those referred to it belonging to the last.

CASTLETON GARDENS.

JUNE.

In Flower.	In Fruit.
Allamanda Hendersoni, Bull.	Amherstia nobilis, Wall. (Amherstia; India and Malacca.)
Averrhoa Carambola, Linn. (Carambola; East Indies)	Cananga odorata, Hook. f. & Thoms. (Cananga, Ilang; India)
Baphia nitida, Lodd. (Cam-wood; W. Africa)	Castilloa elastica, Cerv. (Central American Rubber; Centr America)
Bassia latifolia, Roxb. (Mahwah tree; India)	Cinnamomum zeylanicum, Nees. (Cinnamon; Ceylon)
Bauhinia variegata, Linn. (Butterfly tree; India and China)	Cordia Myxa, Linn. (Sebesten Plum; India)
Brownea Rosa-de-monte, Berg.	Diospyros discolor, Willd. (Mabola Ebony; Philippines)
Cananga odorata, Hook. f. & Thoms. (Cananga, Ilang; India)	Eugenia javanica, Lam. (Wax Jambo; Malay Islands)
Caryocar nuciferum, Linn. (Souari or Butter Nut; Guiana)	Hevea brasiliensis, Muell. Arg. (Para Rubber; Brazil)
Chrysalidocarpus lutescens, H. Wendl. (A Madagascar Palm)	Imbricaria maxima, Poir.
Couroupita Guianensis, Aubl. (Cannon Ball Tree; Guiana)	Michelia Champaca, Linn. (Champac tree; India)
Derris dalbergioides, Bak.	Mimusops Elengi, Linn. (Elengi; E. Indies)
Dipteryx odorata, Willd. (Tonquin Bean; Cayenne)	Morinda citrifolia, Linn.
Eugenia caryophyllata, Thunb. (Clove Tree; Moluccas)	Myristica fragrans, Houtt. (Nutmeg; East Indies)
Eugenia malaccensis, Linn. (Malay Apple; Malay Islands)	Omphalea triandra, Linn. (Cob-nut; Jamaica, Guiana)
Fagræa obovata, Wall.	Posoqueria longiflora, Aubl.
Garcinia Mongostana, Linn. (Mangosteen; Malay Archipelago)	Spathodea campanulata, Beauv. (Spathodea; Trop. Asia and Africa)
Gardenia lucida, Roxb.	

IN FLOWER.	In Fruit.
Gmelina asiatica, Linn.	
Heritiera macrophylla, Wall. (Looking-glass tree; India & Africa)	
Hevea brasiliensis, Muell. Arg. (Para Rubber; Brazil)	
Lagerstrœmia Flos-reginæ, Retz. (Queen's Flower; India & Burma)	
Lagerstrocemia indica, Linn. (Crape Flower; India)	
Mesua ferrea, Linn. (Naghas Tree; India)	
Michelia Champaca, Linn. (Champac tree; India)	
Mimusops Elengi, Linn. (Elengi; E. Indies)	
Mussænda frondosa, Linn.	
Mussænda luteola, Delile	
Norantea Guianensis, Aubl. (Norantea; Guiana & Brazil)	
Omphalea triandra, Linn. (Cob-nut; Jamaica & Guiana)	
Oncoba spinosa, Forsk.	
Oreodoxa regia, Mart. (Royal Palm; Cuba)	
Pachira aquatica, Aubl. (Pachira; Trop, America)	
Plumeria rubra, Linn.	
P. acutifolia, Poir.	
Pterocarpus indicus, Willd. (Rose-wood; East Indies & China)	
Stifftia chrysantha, Mikan.	
Swartzia grandiflora, Willd.	
Tabernæmontana longiflora, Benth.	
Taberæmontana Wallichiana, Stud.	
Tecoma stans, Juss.	

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The proportions of Chlorine & of Nitrogen as Nitric Acid & as Ammonia in certain tropical rain waters, by J. B. Harrison and by J. Williams. [J. B. Harrison.

Seeds.

From Royal Gardens, Kew.
- Romneya Coulteri
- Dendromecon rigidum
- Dicentra chrysantha

From Messrs. Reasoner, Bros. Florida.
- Melia azedarach, var. umbraculiformis
- Zamia integrifolia
- Cinnamomum Camphora
- Hibiscus sp.

From Agri. Hort. Society of India.
- Aristolochia indica

From Botanic Station, Barbadoes.
- Furcræa macrophylla

From Botanic Gardens, Saharanpur.
- Desmodium argenteum
- " sp.
- Cedrela serrata
- Dioscorea sp.
- Rhamnus davuricus
- Bosia Amherstiana
- Milletia racemosa
- Cornus oblonga
- Berberis aristata
- Barleria cristata
- Rhus succedanea
- Platanus orientalis
- Salix Wallichiana
- Aeschynomene indica.

JAMAICA.

BULLETIN

OF THE

BOTANICAL DEPARTMENT.

New Series.] APRIL, MAY, JUNE, 1897. Vol. IV. Parts 4, 5, 6.

SATIN WOOD.

FAGARA FLAVA, Kr. & Urb.

For some long time attempts have been made through various correspondents to obtain specimens of the flowers and seeds of Satin Wood, in order to determine exactly what the commercial Satin Wood of Jamaica is.

Satin Wood in squared logs of good quality is worth £6 to £7 a ton in the London market, and numerous have been the enquiries from all parts of the island about the appearance of the tree, and how the wood may be recognised.

At last Mr. Cecil Isaacs, introduced Mr. E. G. Nixon, who was well acquainted with the Satin Wood exported from Milk River. He very kindly sent specimens of the wood, and of the seed-vessels attached to the leafy branch. The flowers have not come to hand yet, but the material was sufficient to identify the tree, with *Fagara flava* Kr. & Urb. It is only mentioned by Grisebach in his "Flora" as a native of Guadeloupe under the name of *Zanthoxylum Sumach*, but is described and figured by Mr. C. S. Sargent, in his magnificent work, the "Silva of N. America," as a native of certain keys off the coast of Florida.

DESCRIPTION.

The TREE is said to be from 12 to 35 feet high, with a trunk 6 to 18 inches in diameter. It has no spines like most of the "yellow woods."

The WOOD may be described as follows:—

Bark.— Of a light grey colour, surface somewhat smooth with longitundinal furrows and transverse cracks.

Pith.—Scarcely any.

Heart Wood.—No distinct heart wood, but the colour gradually deepens from a light yellow at the bark inwards to a light orange at the centre.

Medullary rays.—These lines in the cross section proceeding from the pith towards the bark, are not continous from pith to bark, but gradually die out in either direction, and are replaced by others. There are about 30 in a breath of ¼ inch.

Annual rings.—Marked off by circles of denser tissue which are of

about the same general breadth and colour as the medullary rays. The rings themselves vary very much in breadth.

Vessels.—Appearing in the cross section as minute dots, requiring a lens to see them, numerous and evenly dispersed in the rings. The rays, rings, circles of denser tissue and vessels are shown in the accompanying illustration which is magnified from a portion of wood measuring about $\frac{1}{3}$ inch long, and $\frac{1}{6}$ to $\frac{1}{4}$ inch broad.

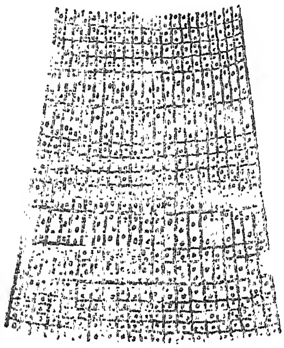

Fig. I.
PORTION OF CROSS SECTION
OF WOOD, MAGNIFIED.

Grain.—Even-grained, of a satiny lustre in longitudinal section, capable of receiving a beautiful polish.

Odour—Aromatic, like the true Satin-wood of the East Indies, when first cut.

Weight.—Heavy. " The specific gravity of the absolutely dry wood is 0.9002, a cubic foot of the dry wood weighing 56.10 pounds,". (Sargent).

The LEAVES are composed of 2 to 4 pairs of leaflets and a terminal leaflet. The leaflets are ovate-lanceolate in outline. But the characteristic which will enable any one to determine this species by the leaf alone from other species in Jamaica, is that when the leaflet is held up to the light, it is seen that it is very numerously dotted with pellucid glands.

The FLOWERS in terminal panicles are either staminate or pistillate and these occur on separate trees. The petals are greenish-white and are turned back over the minute calyx-lobes. (The details in the illustrations of the flowers and seeds are taken from Sargent.)

Staminate flowers.—The Stamens are 5 in nnmber, and there is a rudimentary ovary. *See Fig. II.*

Pistillate flowers.—The pistil is composed usually of 2 carpels with short style and spreading entire stigma, each cell with 2 ovules side by side. There are no stamens. *See Fig. III.*

Seed-vessel.—Only one carpel, as a rule, ripens into fruit with a single black lustrous seed. *See Fig. IV.*

This species is found in, Bahamas, St. Domingo, Porto Rico, Montserrat, Guadeloupe, Martinique, St. Lucia, and Florida besides Jamaica

Fig. II. Staminate Flowers

Fig. III. Pistilate Flowers.

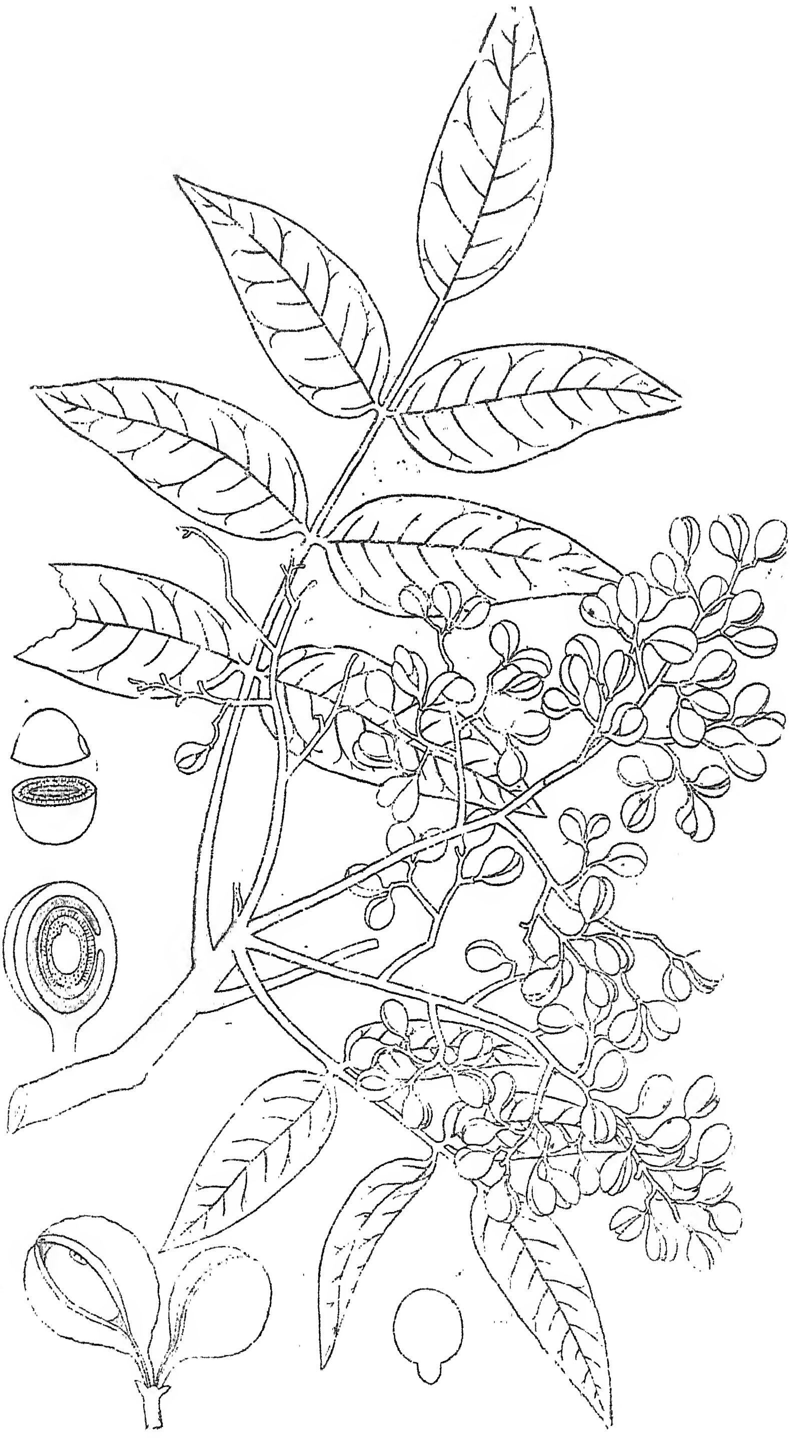

Fig. IV. Seed Vessels.

PEA-NUT OR PINDAR-NUT.

(ARACHIS HYPOGAEA, Linn).

Description.—A prostrate annual herb, belonging to the Pea Family (*Leguminosæ*) with pinnate leaves and yellow flowers. When the pod begins to form, the stalk curves over and buries the pod in the ground, where it ripens. It is naturalised or wild in all tropical countries. More than 100,000 acres are devoted to the cultivation of this plant in India and immense tracts in West Africa.

Soil.—A sandy soil with certain quantity of lime makes the best soil. Marl is one of the forms of lime which suits well, but there must be sufficient sandy material to make the soil porous. Clayey land will produce good crops, if it is thoroughly well dug up and cultivated, but the pods are not of such good colour. It is well to choose land that is thoroughly clean from previous cultivation.

Analysis—The percentage analysis of the ash of the Pea-nut is given by Prof. Cornwall as follows:—

Silica	...	1.06
Potash	...	44.73
Soda	...	14.60
Lime	...	1.71
Magnesia	...	12.65
Phosphoric Acid	...	17.64
Sulphuric Acid	...	2.53
Chlorine	...	0.15
		95.07

Seed.—It is necessary to sow good seed, and in order to test it, a hundred seeds should be picked out at random and sown. From the number that germinate, it can be calculated what is the probable percentage of good seed.

In breaking open the pods, care must be taken not to bruise the kernel, and all shrivelled and dark-coloured kernels should be rejected. After shelling, the seed should be kept for sowing in small parcels only, as large quantities together ferment and lose their power of germination. A bushel to a bushel and a half of pea-nuts in pod are sufficient to plant one acre.

Planting.—The time for planting is before the rainy season. In west Africa where it is grown on a large scale sowing takes place in October; the first crop of nuts for eating green is ready about April, but they are not ripe till 9 months after sowing, or about July or August. In the southern United States, planting takes place in April.

The land should be ploughed and harrowed, more than once if necessary, until a fine mellow seed bed is prepared; but cultivated on a small scale, it is frequently only hoed.

In the United States it generally follows some such crop as corn, cotton, or tobacco, so as to get a soil that has been well hoed, and is quite clean without roots, stones, bush, or any rubbish.

The seed should be sown a foot or 15 inches apart, in rows 3 feet asunder, in hills slightly raised above the surface. One inch deep for the seed is enough in moist soil, one and a half inches in dry soil.

Lime is necessary, and may advantageously be applied in the form of marl.

Cultivation.—When the plants are about two weeks old it will probably be quite time to hoe the weeds, and loosen the soil round the plants, and this must constantly be attended to—the object being to keep the soil mellow and loose, and clear of all weeds. Hoeing and weeding should only cease when the pea-nut vines have almost met from row to row.

Harvesting.—In Virginia the practice is to use a plough "with a point having a long narrow wing and a small mould-board, so that the vines will be loosened without having any earth thrown upon them. The plough passes along on both sides of the row, just near enough for the wing to fairly reach the tap root, which it severs. Care is taken to put the plough deep enough to pass under the pods without severing them from the vines." The vines are then raised with a fork, and after the earth is shaken off, they are laid down in the sun to cure.

Sorting.—The brightest and soundest pods should be kept separate. The dark and immature pods are kept together, and empty pods are rejected with the vines to make hay.

Oil.—A bushel of pea-nuts (twenty-two pounds in the hull) put under the hydraulic press will yield one gallon of oil, more limpid than olive oil, and resembling it. It is largely used to adulterate olive oil and as a substitute for it both medicinally and for alimentary purposes. The best sells in Germany for from 2s. 6d. to 4s. per gallon. It is also employed in the manufacture of soap.

Yield.—The yield is stated to be 50 bushels per acre and from 1 ton to 2 tons of excellent hay.

Food.—After the expression of oil, the residue may be made into meal which is richer than peas, and even lentils, in flesh-forming constituents, and contains more fat and phosphoric acid. The cake is also recommended for cattle feeding.

The value of the pea-nut is indicated by the following percentage analysis :—

Food constituents in different parts in water—free substance.

—	Ash.	Protein.	Fibre.	Nitrogen free extract.	Fat.	Nitrogen.
	per ct.	per ct.	per ct.	per ct.	per ct.	per ct.
Kernels .	2.77	29.47	4.29	14.27	49.20	4.67
Vines (with leaves) .	10.64	12.63	22.32	48.34	6.07	2.02
Meal .	5.48	52.49	6.93	27.26	8.84	8.40

In the United States the nuts are pounded up in a mortar, and are said to make an agreeable chocolate.

Roasted in the shell the nuts can be used at dessert.

The leaves and branches are excellent fodder, and the hay increases the milk of cows. Those who intend to take up the cultivation on a large scale should consult "The Peanut Plant," by B. W. Jones, published by Orange Judd Co., New York.

OIL TREE.

PRIORIA COPAIFERA, Griseb.

Grisebach, in his Flora of the British West Indies, describes this tree as a new genus, naming it after Dr. Alexander Prior. who possessed a very large private herbarium of Jamaica plants, constantly referred to in the Flora.

The specimen from which the genus was described, was supplied by Mr. Nathaniel Wilson, Island Botanist, who found it growing at Bachelor's Hall near Bath.

Mr. Wm. Harris in a collecting tour which he made sometime ago round the east end of the Island, found it at Mansfield, the property of Mr. A. H. Groves, and in his report thus describes it :—

" At Mansfield, near Bath we found large trees *Prioria copaifera.* " The trees were in flower at the time of our visit, and to procure spe- "cimens a monster over 80 feet high with a girth measurement of " about 20 feet near the base had to be felled. This tree proved to be " hollow for a good way up the trunk. It is known as the " oil tree" "in the Bath district. When tapped at certain seasons of the year, it " is said to yield a copious supply of an oleo-resinous inflammable juice, " which was formerly used by the negroes for burning in lamps, but " it emits a very disagreeable odour."

Mr. Groves was kind enough get some of the "oil" for me which was sent to Prof. Trimble, and the following preliminary report on it has been received :—

REPORT ON AN EXUDATION FROM PRIORIA COPAIFERA, GRISEB.,
By HENRY TRIMBLE, Philadelphia.

The sample as received from Mr. Fawcett, was a thick, adhesive liquid resembling copaiba in appearance. Upon standing it separated into two layers; when thoroughly mixed it became turbid on account of a greenish substance which it held in suspension; on the subsidence of this greenish substance, the upper layer, which constituted by far the greater part of the sample, became clear and of a brownish yellow colour.

The material had no pronounced odour, but it imparted a fatty taste at first, which gradually became acid. It did not behave like a gum resin when masticated. In thin layers it was transparent with a pale straw-yellow colour. On exposure to air it dried superficially with a decrease of adhesiveness.

On carefully igniting a portion of the sample it yielded 0.075 per cent. of ash, consisting of calcium carbonate and sulphate with traces of the corresponding magnesium and potassium salts. The combustion was attended with the production of a very sooty flame.

The original material was found to be readily soluble in absolute alcohol, ether, chloroform, carbon disulphide, petroleum ether, amyl acetate, ethyl acetate, methyl acetate, amyl alcohol, benzol, toluol, nitrobenzol, aniline, acetone, phenol, oil of turpentine, cotton seed oil (therefore probably fixed oils in general), glacial acetic acid and oil of camphor. Alcohol of specific gravity 0.820 did not completely dissolve it. The portion left undissolved appeared to be the substance causing the turbidity of the sample. Absolute alcohol and choroform dissolve this residue. The solution in alcohol sp. gr. 0.820, had a

brownish-green fluorescence. Water, glycerin, 36 per cent. acetic acid, and 85 per cent. phosphoric acid failed to dissolve the original material.

Aqueous solutions of sodium and potassium hydrates and ammonia water produced white insoluble mixtures. Potassium hydrate in alcohol dissolved it with the exception of a few white flakes. Magnesium oxide and water formed a solid mass. as did also potassium hydrate when it was fused and the material added to it; the resulting mass showed no tendency to liquefy by further heating, nor would it dissolve in water.

The original material appeared to be separated from this mass by treating with diluted acid in excess, shaking with ether; separating and evaporating the ethereal layer.

About 60 grammes of the original material were mixed with water in a flask, the latter attached to a condenser and heat applied; the water distilled over, leaving the material in the flask apparently unchanged. No oily layer separated from the distillate, thereby indicating the absence of volatile oil, and determining at once the important distinction of this substance from copabia balsam. The distillate was practically clear and colourless, neutral to litmus paper and gave no colour with ferric chloride. An aromatic odour was exhaled during the distillation, and was to a less degree noticeable in the distillate. The water remaining in the flask with the material had the same properties as the distillate, and had dissolved nothing. Heat was then further applied to the flask and its contents until all the water was removed, the temperature was then increased and the material, by a decomposition similar to that known as "cracking" in the distillation of petroleum, distilled until about 90 per cent. had passed into the receiver. The residue then began to "coke" and emit smoky vapors The black tarry residue solidfied on cooling. The last portion of the distillate had a reddish colour and a strong fluorescence similar to that seen in paraffin oils; the odour of this portion was distinctly that of petroleum. The first portions of the distillate were yellow and and had an aromatic odour; these were mixed and redistilled. Distillation began at about 150° C. about three-fourths of the mixture passed over between that temperatnre and 360° C. When this point was reached the residue in the flask had a reddish colour, a petroleum-like odour and fluorescence like the previously described fraction. Both processes were evidently accompanied by destructive distillation.

The specific gravity of the original material was slightly higher than water, although it floated on the latter liquid, owing, no doubt, to occluded air. No nitrogen was found to be present. The substance is either a resinous body very poor in oxygen or else a hydrocarbon, or a mixture of several of them. Its physical properties no doubt suggested a resemblance to copaiba, and therefore the specific name of the tree but in composition and other chemical properties it bears no relation to either copaiba balsam or gurjun balsam. Its behaviour under high temperature indicated some relationship to the fixed oils (see Sadtler on the Destructive Distillation of Linseed Oil, *Am. Jour. Pharm.* 1896 page 485). It is probably medicinally inert.

Philadelphia College of Pharmacy, April, 1897.

CONEYS AND NUTMEG TREES.

A correspondent in the east of the island complains of the bark of his Nutmeg trees being stripped off apparently by the native coney. The following from an American agricultural publication is suggestive :—

Our correspondence indicates that mice and rabbits are often serious pests. Banking up the trunks in the fall from 12 to 15 inches with earth so as to form a mound with steep sides is a good safeguard against mice. This is easily done and also protects the roots on young trees. The mound should be leveled in the spring. To guard against rabbits it is a good practice to wash the stem in the fall with whitewash, thickened with copperas and sulphur. This wash should be renewed as often as necessary, if washed off by heavy rains. These two methods have long been used by many orchadists in the Northwest. The last few years, however, wire cloths such as is used for screen doors, has come into favour in several large orchards. The wire cloth is cut so as to lap over and allow for several years' growth; the sheath is set into the ground about one inch, extends up the full width of the wire screening, and is fastened near top and bottom with wire. This guards against both mice and rabbits and has proven inexpensive and effective. The whitewash can be used if necessary above the wire screening on the stem and main limbs. G. A. Tracey, of Watertown, writes in the Dakota Farmer :

"For rabbits I have for the past twelve years used liver, either hog or beef. I take a piece and go through the orchard, rub it on some of the limbs and bodies of the trees, but do not put it nearer than two or three feet of the ground, for fear of the mice, for they will eat it and the bark with it if it is near the ground. I have failed yet to find a single instance where a rabbit has been nearer than four or five feet of a tree so protected. I use tar paper around the trees, or a little earth banked up around them to protect from mice In using tar paper on small trees I put a stick on the south side to hold the paper a little away from the bark, I have used other remedies, but none suit me so well or is as quickly done as the above."

The use of tar paper in orchards is very generally condemned by fruit growers as it often proves very destructive to the bark, especially on young trees.

Commenting on the above, A. J. Phillips, West Salem, Wis., Secretary of the Wisconsin Horticultural Society writes; "I am inclined to give you the benefit of my experience for the past fifteen years, which, if followed, will be useful to many of your readers. Liver, tar paper, white wash, carbolic acid and Paris green, all fade into insignificance when compared with a good protector made of eight lath woven together with common broom wire, and placed around the trunk of the tree. The length of the lath is to be guaged by the height of the limbs of the tree. This protects against sunscald, rabbits, mice and sheep; plenty of air goes in between the lath. After seven to ten years the tree will fill it full and the bark will be smooth and green under the same, and I never yet have found a borer in a well protected tree of this kind. Banking the earth is a delusion nine times out of ten, as the grower fails to remove it and it remains and sods over with June

grass, which soon takes away from the tree all the moisture that fall so that the feeding roots never find it. Protection of this kind is always on and costs half a cent per year. And a tree, when half a cent would save it, I ask, who is willing to lose it?"

If the laths have a tendency to rub the bark they may be kept in place by a bunch of hay stuffed in at the top.

NOTES ON RECENT ADDITIONS.

IRVINGIA BARTERI, Hook. f.—This is the "Wild Mango" of the natives of Sierra Leone. The fruit is about $2\frac{1}{2}$ inches in diameter, and is said to be edible. The stem contains a seed from which an oily preparation can be extracted, something like Cocoa butter. The tree is from 30 to 50 ft. high with small yellow flowers, and belongs to the same family as Bitter wood and Mountain Pride (*Simarubeæ*).

It was first collected by Mr. Charles Barter, attached to the Niger Expedition of 1857-59, and the species was named after him.

Seeds presented by Director, R. Gardens, Kew.

KICKXIA AFRICANA, BENTH.—This is one of the African rubber trees widely distributed from Sierra Leone to the Gold Coast and beyond the mouths of the Niger to the Bight of Biafra. The native name of the tree is Ire, Ireh, or Ereh. It is said to be one of the most beautiful trees in the forest, and from the ground it grows evenly in bulk and smoothly to the height of 60 to 70 feet.

In the rainy season when the trees are full of milk, a tree well tapped is capable of producing from 10 to 15lbs of rubber, which is worth 1/ per lb., on the spot if properly prepared, and 2/, to 2/4 in English markets if made into biscuit.

This valuable rubber tree belongs to the same family as the Jamaica Milk Wythe (*Apocynaceæ.*) Seeds presented by Director, R. Gardens, Kew, and Mr. Hartley of the Lagos Botanical Station.

Acacia mollissima Willd.—This is the *Black Wattle.*—By cutting out the branches in Wattle-plantations the needful thinning is obtained. The bark of this tree is rich in tannin, the average proportion of mimosa-tannic acid in absolutely dry bark is 30.08. For full information on Wattles and Wattle-barks see Bulletin for September, 1890. Seeds presented by Director, Botanic Gardens Sydney, N. S. W.

REASONS FOR CULTIVATING THE SOIL.

By Milton Whitney.
Chief of the Division of Agricultural Soils, U. S. Department of Agriculture.

From Year Book for 1895.

HOW WATER ENTERS THE SOIL.

Water is the most abundant substance found in living crops. Not only does it form by far the largest proportion of all fresh vegetable substance, but, on account of loss through evaporation from the leaves of growing plants and the necessity of replacing this loss, thirty or forty times more water is needed during the growing period of a crop than is contained in the crop when harvested. Plants require a large amount of water for their life and growth, and it is necessary that the supply should be abundant at all times. If the evaporation from the plant grately exceeds the amount taken in through the roots, the leaves wilt and the plant suffers.

Therefore one of the most important functions of the soil in its relation to crop production is the maintenance of a proper supply of water. Rain falls, on an average, in the humid portion of the United States for two or three days in succession, and is then followed by an interval of eight or ten days of fair weather. As plants are fixed in their relative positions in the earth, the soil, in order to supply them with water during the fair-weather period, has to offer such a resistance to the percolation of the rain than an adequate supply shall be held back. On account of this resistance, due to the friction which the rain encounters in the minute spaces between the soil grains through which it has to pass, the movement is very slow and only part of the water sinks below the reach of plants before the next rainfall occurs.

The resistance which soils, owing to their difference in texture, offer to the percolation of the rain varies greatly. Light, sandy soils maintain comparatively little moisture, because the spaces between the grains are comparatively large and there is relatively but little resistance to the flow of water, so that the rainfall moves down quite rapidly until there is only 5 or 10 per cent of moisture present in the soil. Strong clay soils, on the other hand, have very minute spaces for the water to move through, and consequently offer a very great resistence to the percolation of the rain. These soils maintain, as a rule, from 15 to 20 per cent of their weight of water.

Different plants grow best with different amounts of water. For instance, the pasture grasses thrive on a soil which is too moist for Indian corn, or even for the largest and surest yield of wheat. Some classes of tobacco thrive well on soils which are very retentive of moisture, while other classes can only be grown with success on drier soils. We are not concerned in this article with the amount of moisture which different soils maintain or with the amount of moisture required by different kinds of plants. We must recognize, however, that it is not possible nor desirable to maintain the same amount of water in all soils, for if this were done there would not be the opportunity for diversity in agriculture which we have under existing conditions.

While water is maintained for a time in the soil, as already explained, it is liable to be lost to the growing crop by evaporation from the sur-

face of the ground or by being used up by weeds. The end sought in ploughing and cultivation is to control the water supply by removing weeds and leaving the surface of the soil covered with a loose, dry mulch to retard evaporation. Many of our crops require no subsequent cultivation after they are put into the ground. Wheat, oats, rye, clover, grass, forest trees, and, in general, such crops as cover and shade the ground are not, as a rule, cultivated during their period of growth. On the other hand, such crops as corn, tobacco, cotton, potatoes, and fruit trees require cultivation during their early growing period, although even with these crops cultivation ceases after they have attained considerable size, and is rarely practiced during the ripening period.

The principal object of ploughing is to loosen up the soil, for four purposes: (1) To enable the soil to absorb the rainfall more quickly and more freely than it would in its undisturbed condition; (2) to maintain more of the rainfall near the roots of plants; (3) to admit fresh air to the roots of plants; (4) to enable the roots of the young or quickly growing plants to penetrate the soil more easily.

The principal objects of subsequent cultivation, whether with plough, cultivator, cotton sweep, harrow, hoe, or rake, are (1) to prevent loss of water by weeds and grass, which use up great quantities; (2) to keep the surface covered with a loose, dry mulch in order to prevent, so far as possible, loss of water by evaporation. Water is thus conserved for the use of crops, and the supply is more abundant and more uniform than it would have been without the cultivation.

A soil with a compact surface quickly dries out, and the water supply fluctuates rapidly and excessively, to the detriment of most crops during their growing period. Weeds and grass are generally to be excluded from the crop because they transpire great quantities of water which would otherwise have been at the disposal of the crop. Weeds are, however, occasionally of advantage to the crops, especially during the ripening period, because they help to dry out the soil and thus hasten the maturity of the crop.

Some of our crops, therefore, do not require cultivation, because they shade the ground and prevent evaporation and prevent grass and weeds from springing up and diminishing their supply of water, or because they are deeply rooted and can bring water up from considerable depths. Other crops can not protect their water supply in this way, and it must be artificially controlled by methods of cultivation. . .

PRINCIPLES OF PLOUGHING.

The common plough is essentially a wedge-shaped instrument, which is forced through the soil to loosen it. The topsoil is forced aside thrown up, and usually turned over. This action loosens the soil by separating the soil grains. The loose soil occupies more space than the compact soil did, and a cubic foot of the former, therefore contains more space for water to enter. Each separate space, however, is also larger and has less capillary action and a smaller power of drawing water to the surface. If the soil, by reason of its fine texture or wet condition, is lumpy after the ploughing, the spaces in the soil will be of very uneven size, and it frequently happens that the surface of the ground is not left in a suitable condition to draw water up from below

If small seeds are sown on such a rough surface, they are liable to suffer for lack of moisture. It is customary, therefore, and very advisable in such cases, to harrow and roll the seed bed until all the larger lumps are broken down and the surface is left smooth and even, in order to insure a supply of moisture to the seed during the germinating period. However, soil which has thus been rolled will lose more water by evaporation than soil which has been simply harrowed. The evaporation of this moisture is an incident which it is not always possible or desirable to prevent. With some crops the surface may be harrowed after the seed has germinated. This is desirable when it can be done without injury to the crop, as it tends to retard evaporation.

There is one serious defect in the principle of the common plough which, upon some soils and with certain kinds of ploughing, is liable to have very serious effects. If a field is ploughed for many successive years to a depth of 6 or 8 inches the tendency each time is to compact the subsoil immediately below the plough, thus rendering it more impervious to water; that is, the plough in being dragged along plasters the subsoil just as a mason with his trowel would smooth out a layer of cement to make it as close and impervous to water as possible. This is undoubtedly an advantage to some soils, but, on the other hand, it is very injurious to many.

The injurious effect of this compact layer formed by the ploughing is twofold. It makes it more difficult for the rainfall to be absorbed as rapidly as it falls, and increases the danger of loss of water and injury to the soil by surface washing. Soils ploughed at a depth of 3 or 4 inches, which is quite common in many parts of the country, would have a thin layer of loose material on the surface, with a compact subsoil below, into which water would descend rather slowly. With a rapid and excessive fall of rain, the light, loose topsoil is liable to be washed away by the excess of water, which can not descend into the subsoil as rapidly as it falls. This washing of the surface and erosion of fields i to gullies occasion the abandonment of thousands of acres of land. The fi ld will not wash so badly if it is not ploughed, and, on the other hand, it will hardly wash at all if the cultivation is deeper and the subsoil left in a loose and absorbent condition. The deeper the cultivation, the greater the proportion of rainfall stored away and the less danger of the erosion of the surface soil and the less serious the defect of our common method of ploughing. While there is less danger from washing, however, with deep cultivation, there is still a tendency towards the formation of a hardpan at whatever depth the land is ploughed. No simple modification of the ordinary plough or of the subsoil plough will overcome this defect. It will require a change in the very principle of the implement. The plough should not cut through the soil, but break it apart so as neither to compact nor puddle it by being dragged along over the subsoil.

While all other farm implements and machinery have been improved, especially within the last fifty years, so that we are able now to harvest more crops than ever before and to handle our crops to better advantage, our common plough has not been essentially improved or modified in any important particular, except as to mechanical construction, since the days of the early Greeks and Romans. It would seem only necessary to call attention to this, the

fundamental and simplest principle of agriculture, to have some new method devised of stirring the soil without compacting the subsoil.

The highest art of cultivation which has ever been practiced is that of trenching, so extensively employed in England and so earnestly advocated by the early English writers on agriculture. With a large class of lands there is no implement so effective for loosening and improving the soil conditions as the spade. The spade does not cut the soil from the subsoil as the plough does, but breaks it off, and there is little or no disturbance and no compacting whatever below that point. Every one is familiar with the difference in the tilth of a garden which has been thoroughly spaded and of a field ploughed in the ordinary way. This old method of trenching with a spade can not, of course, be used in the extensive systems of cultivation practiced in this country, and it is now used in England much less than it was years ago, but if this principle could be worked into a practical method of cultivation it would be of great benefit to agriculture.

PRINCIPLES OF SUBSOILING.

At the present time little is known definitely about the practical value of subsoiling. In certain localities it has or has not been found to be beneficial to crops. There is a wide diffierence of opinion upon this fundamental point. Fifteen or twenty years ago it was very generally advocated throughout the East by all of the agricultural journals. It was tried in a great variety of soils and under many conditions, and there is no doubt that in perhaps a majority of cases it showed no beneficial effects. This might have been expected, for no one method of cultivation can be equally valuable under the various conditions of soil, climate, and crops such as prevail over such a great extent of country. At the present the subject is being prominently agitated in some of the Western States, particularly in the semiarid regions, and very favorable results are being reported through the local agricultural papers.

A few general principles only may be laid down for guidance in this matter. Subsoiling is rarely necessary in light, porous, sandy soils or in a climate where they are frequent light showers. It is not beneficial in heavy, wet soils, unless they are previously thoroughly underdrained. It is likely to be injurious if in the operation much of the subsoil is brought to the surface and incorporated in the surface soil, especially if the subsoil itself is in an unhealthy condition as regards drainage and contains poisonous matters which would be deleterious to plant growth. Poisonous matters frequently occur in subsoils as a result of improper aeration and the growth of certain minute organisms.

Subsoiling when properly done consists merely of breaking up the subsoil without bringing it to the surface or in any way incorporating it with the upper layer of the soil. In this respect it differs from deep ploughing. The ideal subsoil plough consists merely of a tongue fashioned much like a common pick and hardly larger in its demensions—slightly smaller at the point than in the rear, but as small in all its parts as is consistent with perfect rigidity and with the nature of the soil through which it is to be drawn. This usually follows an ordinary plough. It should be run at as great a depth as possible, the

endeavour being to get it at least 16 or 18 inches below the surface. It is often advisable by this means to break up a hardpan formed, perhaps, by long-continued ploughing at a uniform depth or existing as a natural formation below the surface.

Subsoiling is likely to be beneficial, under the prevailing climatic conditions east of the Mississippi River, in any soils of medium or of heavy texture, provided the land has fairly good drainage. In the semiarid region of the West it is likely to be very beneficial upon many classes of soils, especially where the rainfall occurs in heavy and infrequent showers and where it is necessary to increase the capacity of the soils to absorb water readily and rapidly.

Subsoiling, to be efficient, should be done a sufficient length of time before the crops are planted to insnre to the soil a thorough soaking with rain; otherwise it may injure rather than improve the soil conditions for the first year. Subsoiling, by stirring the land to an unusual depth, favours the drying out of the soil, so that if it is not supplemented by a soaking rain before the seed is put in, the ground is drier than if the work had not been done.

There are few places in the West where this practice has been carried on long enough and under conditions necessary for beneficial effect. One such place, however, is at Geneva, Nebr., where subsoiling has been intelligently carried on for a number of years under nusery stock. The records of soil moisture which have been made at that place by this division through the present season show that on the average, through the months of June, July, and August, there was 10 per cent of moisture in the soil to a depth of 12 inches where ordinary methods of cultivation had been used, and 15 per cent where the land had been previously subsoiled No crops were growing on the soils from which the record were kept in either case. This difference of 5 per cent in the amount of water, or 50 per cent increase over that in the uncultivated soil, is a very large amount and would doubtless have a very important effect upon the crop yield. This is confirmed by the actual yields on the two soils, as reported by Younger & Co., on whose farm the observations were made.

Further work will be done along these lines by this division, to establish these general principles. In the meantime great care and judgment should be exercised in deciding upon whether it is advisable to adopt this practice in every case.

CULTIVATION.

Cultivation as here used means the actual stirring of the surface after the crop is planted, either with a plough, cotten sweep cultivator, harrow, hoe, or other implement The object of cultivation is twofold—to destroy weeds and thus prevent the great drain which they make upon the soil moisture, and to loosen and pulverize the surface, leaving it as a fine mulch, the object of which is to prevent evaporotion. The first of these objects needs no further comment here. As regards the second object of cultivation, the result to be attained is to have the surface covered with a fine, dry mulch before the dry spell sets in, so as to conserve the water in the soil during dry periods.

Cultivation is usually most effective in the early stages of the growth of crops especially during the growth of the vegetative parts

of the plant. It is usual to stir the surface after each rain. If another rain follows within a short time, this cultivation may do little or no good; but if a dry season follows, the cultivation may save the crop by its having diminished the evaporation While cultivation does not add water to the soil, as some claim, it prevents excessive loss, and thus maintains more water in the soil, which means about the same thing.

The kind of treatment adapted to the cultivation of different soils depends upon local conditions, climate, and the kind of crop. The object sought is the same in all cases but the means of attaining it must be adapted to the local circumstances. As a rule, cultivation should be shallow, for two reasons, namely, to avoid disturbing the roots of the growing plants, and to avoid losing any more of the soil moisture than possible. A single cultivation after each rain is not necessarily enough, especially if a dry season is expected. The surface must be kept loose and dry, and this may require more than one cultivation, even if there has been no subsequent rain.

Few of our agricultural crops require cultivation after they have attained their vegetative growth, and a crop is frequently injured when cultivation is continued too long, because the soil is thus kept too wet, and the plants are not inclined to ripen as early as they should or to mature as large a yield of fruit or grain Most of our grain crops will mature more seed if the ground is moderately dry during their ripening period.

UNDERDRAINAGE.

A soil containing too much water during the whole or a considerable part of the season should be underdrained to draw off the excessive amount of moisture. Most of our agricultural crops do better in a soil containing from 30 to 60 per cent of the amount of water which the soil would contain if saturated. With less water, crops suffer; with more, they suffer from lack of air around their roots. Wheat may be grown very successfully, and will attain a perfectly normal development in water culture with its roots entirely immersed in a nutritive solution, provided the water is supplied with air at frequent intervals, but it will not grow in stagnant, saturated soil, not because there is too much water, but because there is too little air. A soil, therefore, which contains too much water contains too little air, and part of the water should be drawn off through ditches or tile drains.

Centuries ago the Romans used to overcome this trouble by planting the crop on very high ridges or beds, often 8 or 10 feet high and fully as wide In this way alleys were provided at frequent intervals to carry off the surface water, and the greatest extent of surface was presented for the drying out of the soil, while the roots were kept at a considerable distance from the saturated subsoil. Storer states that some of these ridges are still to be found in localities in Europe. They are used to-day in a modified form in the cultivation of the sea-island cotton off the coast of South Carolina, but are being gradually given up as the practice of underdrainage is introduced, which is cheaper in the end and more effective.

Tile drainage is usually most effective in stiff clay soils and in low bottom lands, but it is occasionally beneficial in medium grades of

loam or even in light sandy soils. It is practiced to a considerable extent in the light sandy soil of the truck area of the Atlantic Seaboard, where the question of a few days in the time of ripening of the crop is an important factor.

IRRIGATION.

If the climatic conditions are such that it is impossible, with the most improved methods of ploughing, subsoiling, and subsequent cultivation, to maintain a sufficient amount of moisture in the soil for the use of crops, it is then necessary to resort to irrigation or the artificial application of water to the soil. It is not the purpose here to enter into a discussion of the best methods of irrigation but simply to discuss briefly the general principles of irrigation as practiced in maintaining proper conditions in the soil.

Our ideas of irrigation should not be confined to the arid regions. To be sure, irrigation is much more important there than elsewhere, for without artificial application of water, crops could not be produced in many localities. In the humid portion of the United States, even in localities in Florida where they have from 60 to 70 inches of annual rainfall, irrigation is used successfully as a means of insuring the crop against drought due to the uneven distribution of the rainfall. It has been pointed out in several publications of this division that where the supply of water in different soils reaches a certain point, which differs according to the texture of the soil, crop suffer for lack of it. In the truck soils of the Atlantic Coast this minimum is approximately 4 per cent, while in the heavy limestone grass lands of Kentucky the pasture begins to dry up when the soils contain as much as 15 per cent of water.

Under our present modes of cultivation the farmer can do little for the crop during the time of actual drought. Ordinary cultivation is of comparatively little benefit during a prolonged dry season. Its most effective work is before the dry spell sets in. No matter what the value of the crop, and no matter how much this value is concentrated on small areas of land, there is practically but little to be done to save the crop. Irrigation should be used as an insurance against the loss of crops. A small pond fed by a wind mill would often save a garden or a small area of a valuable crop from destruction or great injury during a dry season. A small portable farm engine, which would be available at other times for cutting feed, thrashing grain, and other farm purposes, could be used to drive an irrigation pump during the dry seasons. This would be particularly valuable for tobacco, truck, and other crops which are grown under a very intensive system of cultivation.

The object of all cultivation, in its broadest aspect, is to maintain, under existing climatic conditions, a uniform and adequate supply of water and air in soils, adapted to different classes of plants. This is the object alike of ploughing, subsoiling, cultivation, underdrainage, and irrigation; they are all processes to be usod in maintaining suitable moisture conditions for the growth of crops.

COMMERCIAL FERTILIZERS:
COMPOSITION AND USE.

BY

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There is, perhaps, no question of greater importance to the practical farmer than that of soil fertility. To produce profitable crops and at the same time to maintain and even to increase the productive capacity of the soil may rightly be termed "good farming." Many farmers are able to do this, and the knowledge of *how* to do it has been largely acquired through years of experience, during which the character of the soil, its adaptability for crops, and the methods of its management and manuring have been made the subjects of careful study, without, however, any definite and accurate knowledge concerning manures and their functions in relation to soils and crops. Experience is an excellent teacher; still, a definite knowledge of first principles may be substituted for years of experience in the successful use of manures.

THE NEED OF COMMERCIAL FERTILIZERS.

The fertility of the soil would remain practically unchanged if all the ingredients removed in the various farm products were restored to the land. This is to a large extent accomplished by feeding the crops grown on the farm to animals, carefully saving the manure and returning it to the soil, and if it is practicable to pursue a system of stock feeding in which those products of the farm which are comparatively poor in fertilizing constituents are exchanged in the market for feeding stuffs of high fertilizing value, the loss of soil fertility may be reduced to a minimum or there may be an actual gain in fertility.

The following table, showing the amounts of fertilizing constituents in 1 ton of different agricultural products, indicates directions in which such an exchange may be effected with advantage:

Manurial constituents contained in 1 ton of various farm products.

	Nitrogen.	Phosphoric Acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*
Meadow hay	20.42	8.2	26.4
Clover hay	40.16	11.2	36.6
Potatoes	7.01	3.2	11.4
Wheat bran	49.15	54.6	28.6
Linseed meal	105.12	32.2	24.8
Cotton-seed meal	135.65	56.2	29.2
Wheat	37.53	15.8	10.6
Oats	36.42	12.4	8.8
Corn	33.06	11.8	7.4
Barley	39.65	15.4	9.0
Milk	10.20	3.4	3.0
Cheese	90.60	23.0	5.0
Live cattle	53.20	37.2	3.4

The exchange of 1 ton of corn for 1 ton of wheat bran, for instance, with result in a gain of 16 pounds of nitrogen, 43 of phospheric acid, and 21 of potash. With an exchange of milk or potatoes for the concentrated feeding stuffs the gain is still more striking.

A careful study of the present condition of farming in the United States indicates, however, that as a rule the manure produced on the farm is not sufficient to maintain its fertility and that the need for artificial supplies is real, though the amount required may be considerably reduced by careful management.

In the system of so-called "grain-farming" which has obtained over large areas of this country for a long time, and is still practiced in the Eastern, Middle, and Central Western States, the live stock kept is often limited to a number sufficient only to the needs of the farm for labour and food; the grain is sold, and the manure is make up chiefly of the natural wastes, or unsalable material, such as straw, stalks, etc. The grain contains proportionately greater amounts of nitrogen and mineral constituents than these wastes; hence the practice continued for a long time results not only in a deficiency in the soil of organic substances containing nitrogen, but also in an exhaustion of the mineral substances. The original character of the soil and its treatment measure the rate of exhaustion. The less fertile soils of the East and South are rapidly depleted, while the rich prairie and river bottoms maintain their fertility for a longer period.

Special crop farming, as for example the continuous cotton and tobacco growing of the South and the wheat growing of the West, is even more exhaustive, since here the demands upon the soil are not changed—year after year the same crop is grown and the same kind and proportion of constituents are required, while even less returns are made in the way of manure than in the system of farming above described. Moreover, the land is left bare for a large part of the year and loss of fertility from this cause is very large. The crops are less abundant each year, not because the soil is entirely exhausted, but because it is so far exhausted of those constituents essential to the special crop grown that its production is no longer profitable.

Changed conditions of farming, which have an important bearing, on this point, may be observed in two directions—(1) in the increased cost of labour and in the lower prices of grain, cotton, and tobacco; and (2) in the increasing demand for market garden products and fruit. For example, in growing wheat, the labour of preparing the soil, of cultivation, and of harvesting is practically the same whether the yield is 10 bushels per acre or 30 bushels. The same is true of a number of other crops; hence in the larger yield the cost of labour per bushel is materially reduced; meagre crops of a relatively low value can not be produced profitably with high-priced labour. Soils of a high degree of fertility are required in order to produce large yields of these crops. The return to the soil of only the wastes of the farm results sooner or later in a decrease in fertility, however good the management may be; hence the need of supplies of plant food from sources outside the farm in order that maximum crops may be produced.

In the case of market garden crops, it has been proven that even very fertile soils contain too little available food to insure a maximum production; this is especially true where rapidity of growth, earliness, and

high quality of produce are important factors. The areas now necessarily devoted to these crops are so great that the amount of farm manures available is much too small; besides, the constituents contained in such manures, being slowly available, are less useful than the more active forms contained in commercial fertilizing materials. They are in a sense artificial crops and, as a rule, need artificial supplies of plant food.

Fruit culture, an industry of growing importance, is profitable, particularly on the poorer soils near the Eastern markets, largely in proportion to the supply of the mineral elements in excess of those contained in soils otherwise well adapted to the crops. A sufficiency of food not only enables the trees to resist unfavourable conditions, but improves the quality of the fruit and extends the bearing period of the orchards and vineyards.

It will thus be seen that it is either to make up the deficiencies of farm manures or in specialized intensive farming that commercial fertilizers can be most advantageously used. The latter should supplement and not entirely replace the manurial resources of the farm. They give best results as a rule on soils well stocked with organic matter (humus), a material which can be maintained in soil only by the regular application of the bulky farm manures (including green manures).

FERTILIZER REQUIREMENTS OF DIFFERENT SOILS AND CROPS.

Nitrogen, phosphoric acid, and potash are the constituents most likely to be deficient in soils or most quickly exhausted by the production and removal of crops. These are known as "essential" fertilizing constituents, and the value of a commercial fertilizer is determined almost exclusively by the amount and form of the nitrogen, phosphoric acid, and potash which it contains. It does not follow, however, that all soils or crops will respond equally to applications of materials containing these elements, because the needs of soils and the requirements of crops vary.

Soils differ in respect to their needs for specific elements, owing either to their method of formation or to their management and cropping. A sandy soil is usually deficient in all the essential plant-food constituents—nitrogen, phosphoric acid, and potash—while a clayey soil usually contains the mineral elements in abundance, particularly potash. On the other hand, a soil very rich in vegetable matter is frequently deficient in mineral matter, while a limestone soil is likely to contain considerable proportions of phosphoric acid. These are the indications in a general way, and they explain why it is that different kinds of soil that have not been cropped differ in respect to their needs in reference to the different fertilizing constituents.

Methods of management and cropping also exert an influence; for example, soils of equal natural fertility may not respond equally to uniform methods of fertilization, because in the one case a single crop, requiring for its growth proportionately more of one of the essential elements than of another, is grown year after year, and it may be that the element required is the one that exists in the soil in least quantity. On the other hand, crops may be grown that demand but minimum amounts of the element in question; hence its application to the soil for the one crop may be followed by largely increased returns, while for the other but little if any increase in crop is apparent.

In the matter of management, too, a considerable variation may be observed. One soil may lose a large portion of its essential constituents, because no pains are taken to retain for the use of the crop the constituents annually rendered available through the natural agencies of sun, air, and water; while in another, by means of carefnl cultivation and the use of absorbents and catch crops, the constituents made available are largely retained.

Crops differ in respect to their power of acquiring food.—The legumes, a class of plants which includes the various clovers, peas, beans, vetches, etc., differ from other plants in being able, under proper conditions, to acquire their nitrogen from the air, and can therefore make perfect growth without depending upon soil nitrogen. On the other hand, the various grasses and grains are not only dependent upon soil nitrogen, but they must have an abundance during their most rapid period of growth in order to attain their maximum development. For the latter class of plants favourable results are secured from the proper use of nitrogenous manures, while for the former class the application of nitrogenous manures simply results in supplying an element which could have been secured quite as well by the plant itself, without expense. Illustrations could be multiplied, though perhaps less striking than this, showing that the variations in crops in respect to their power of acquiring food are really very great, and a right knowledge of this fact has a most important bearing upon the economical use of commercial manures.

"The most satisfactory, and, indeed, usually the only method" says Armsby, "by which we can at present determine the needs of a soil is to ask the question of the soil itself by growing a crop upon it with different kinds of fertilizers and noting the result. Such soil tests with fertilizers have in many cases given results of much immediate practical value for the locality in which they were undertaken. As a rule, however, farmers have looked upon such experiments as something too costly and complicated for them to undertake, and consequently they have perforce been content to use fertilizers in a more or less haphazard manner, and in many cases, no doubt at a great financial disadvantage."

While such tests are not so difficult or expensive as is often supposed it is recommended that before the farmer undertakes them for the first time he seek the advice of some one familiar with the details of such work.

FORMS, SOURCES, AND COMPOSITION OF FERTILIZING MATERIALS.

The term "form" as applied to a fertilizing constituent has reference to its combination or association with other constituents, which may be useful, though not necessarily so. The form of the constituent, too, has an important bearing upon its availability, and hence upon its usefulness as plant food. Many materials containing the essential elements are practically worthless as sources of plant food because the form is not right; the plants are unable to extract them from their combinations; they are "unavailable." In many of these materials the forms are changed by proper treatment, in which case they become valuable not because the element itself is changed, but because it then exists in such form as readily to feed the plant.

NITROGEN.

Nitrogen is the most expensive of the three essential fertilizing elements. It exists in three distinct forms, viz., as organic matter, as ammonia, and as nitrate.

Organic nitrogen exists in combination with other elements either as vegetable or animal matter. In fact all plants and animals contain nitrogen in this form, and the relative value of the various substances as sources of nitrogen depends upon their content of it and upon the character of the substance and its treatment. All materials containing organic nitrogen are valuable in proportion to their rapidity of decay or change, because decay and change of form must take place before the nitrogen can serve as food. In some cases the decay is longer delayed than in others. The material may be hard and dense, or it may have been treated for the express purpose of preventing decay, or it may be associated with other substances that resist the agents which effect decay. Thus organic nitrogen differs in availability not only according to the kind of material which supplies it, but upon the treatment it receives.

The most abundant supplies of nitrogen occur in organic forms. The most valuable sources of organic nitrogen, from the standpoints of uniformity in composition, richness in the constituent, and availability, are dried blood, dried meat, or azotine, and concentrated tankage, which are produced in large quantities in slaughterhouses and rendering establishments; dried fish, refuse from fish-oil and canning establishments; and cotton-seed meal, the residue of the cotton seed after the oil has been extracted. These vary somewhat in composition, but within comparatively narrow limits (see table, p. 106). They are all rich in nitrogen, and decay rapidly when the conditions are favourable, and are very useful in cases were rapid and continuous feeding of the plant with nitrogen is desirable.

These products, while valued principally as sources of nitrogen, also furnish more or less phosphoric acid, the dried blood and meat showing the least and the fish the greatest amount. Other nitrogenous materials which are less desirable are leather meal, horn and hoof meal, wool waste, felt waste, and similar products. These contain, as a rule, a high content of nitrogen, but they are so very slow to decay that it is doubtful whether their use in their original form is advisable when forms of known value are available at reasonable prices. Where the object is gradually to increase the fertility of the soil rather than to secure immediate returns, they may become useful. Farmers frequently have access to local supplies at a slight cost, the chief expense being the labour of carting and distributing, in which case they are worth considering.

Nitrogen as ammonia exists in commercial manure products in the form of sulphate of ammonia, chloride of ammonia, etc., and is more readily available than organic forms. It is one of the first products that results from the decay of organic substances.

Nitrogen in the form of ammonia is obtained almost entirely from sulphate of ammonia, which is one of the most concentrated materials from which nitrogen is obtained for fertilizing purposes, the commercial product containing on the average 20 per cent. of nitrogen. As already indicated, ammonia is one of the first products in the decay of organic

substances, and this, together with the fact of its concentration, makes the sulphate an extremely valuable form of nitrogen. While it is extremely soluble in water, it is not readily removed from the soil by leaching, except in the absence of growing plants, since it is readily absorbed by organic and other compounds of the soil.

Nitrogen as nitrate exists in commercial products as nitrate of soda, nitrate of potash, etc. These, like the ammonia compounds, are extremely soluble, and the nitrogen contained in them is readily available as food for plants. The nitrogen in this form is directly and immediately available, no further changes being necessary.

The chief source of nitrogen as nitrate is nitrate of soda. This salt is rich in nitrogen, showing on the average 16 per cent, and is quite uniform in composition. It is completely soluble in water, diffuses readily throughout the soil, and differs from the ammonia compounds in forming no insoluble compounds with soil constituents. It is, therefore, liable to be washed out of the soil if applied in too large quantities or when there is an absence of vegetation. Plants that derive their nitrogen from the soil secure it chiefly in the form of a nitrate; hence nitrate of soda is one of the most directly useful of the nitrogenous materials.

As already explained, nitrogen in organic forms is changed into ammonia by the decay or rotting of the substance. Ammonia, while it may nourish plants directly, is usually changed into a nitrate, in which form it is taken up by the plant. An application of nitrogen as nitrates may be completely used by the plant in a very short time; as ammonia or organic matter it may be partially or wholly used in the course of a season, depending upon whether the conditions are favorable for causing the changes that must take place.

PHOSPHORIC ACID.

Phosphoric acid is derived from materials called phosphates, in which it may exist in combination with lime, iron, or alumina as phosphates of lime, iron, or alumina. Phosphate of lime, however, is the form most largely used as a source of phosphoric acid. Phosphoric acid occurs in fertilizers in three forms: That soluble in water and readily taken up by plants; that insoluble in water but still readily used by plants, also known as "reverted;" and that soluble only in strong acids and consequently very slowly used by the plant. The soluble and "reverted" together constitute the "available phosphoric acid. The phosphoric acid in natural or untreated phosphates is insoluble in water and not readily available to plants; that is, the rate of availability depends largely upon the rapidity with which the substance rots or decays, and the rate of decay again depends upon the character of the substance with which the phosphate is associated. If it is combined with organic substance, as in animal bone, the rate of decay is more rapid than if with purely mineral substances. The insoluble phosphates are converted into soluble forms by treatment with strong acids, as explained later. Such products are known as acid phosphates or superphosphates.

Bone, in its various forms, is the only one of the insoluble phosphates that is now used directly upon the soil, or without other change than is accomplished by mechanical action or grinding. The terms used to indicate the character of the bone have reference rather to their mechanical form than to the relative availability of the phosphoric acid contain-

ed in them. The terms "raw bone," "fine bone," "boiled and steamed bone," etc., are used to indicate methods of preparation, and inasmuch as bone is a material which is useful largely in proportion to its rate of decay, its fineness has an important bearing upon availability, since the finer the bone the more surface is exposed for the action of those forces which cause decay or solution, and the quicker will the constituents become available. In the process of boiling or steaming, not only is bone made finer, but its physical character in other respects is also changed, the particles, whether fine or course, being made soft and crumbly rather than dense or hard; hence it is more likely to act quickly than if the same degree of fineness be obtained by simple grinding. The phosphoric acid in fine steamed bone may all become available in one or two years, while the coarser fatty raw bone sometimes resists final decay for three or four years, or even longer. Bone, however, contains considerable nitrogen, a fact which should be remembered in its use, particularly if used in comparison with other phosphatic materials which do not contain this element.

Pure raw bone contains on an average 22 per cent. of phosphoric acid and 4 per cent. of nitrogen. By steaming or boiling, a portion of the organic substance containing nitrogen is extracted, which has the effect of proportionately increasing the phosphoric acid in the product; hence a steamed bone may contain as high as 28 per cent of phosphoric acid and as low as 1 per cent. of nitrogen. Steamed bone is usually, therefore, much richer in phosphoric acid than raw bone.

Tankage is a bone product which, as a rule, contains more nitrogen than bone proper. It is also more variable in its composition, depending upon the proportions of bone and meat used in its preparation. It is not so largely used as a direct fertilizer as bone.

Other phosphates derived from bone, as boneblack, bone ash, etc., are but little used directly as sources of phosphoric acid; for while they are derived from organic sources, the treatment which they have received, besides depriving them of their nitrogen, causes them to be a much less valuable source of phosphoric acid than the various forms of bone already discussed. In both cases the organic substances which show the greater tendency to decay have been removed—in the case of boneblack by heating the bone in air-tight vessels, and in bone ash by burning in the open air.

The mineral phosphates differ from what may be termed "organic phosphates" in that they contain no organic or animal matter, and that they are more compact and dense in their nature. The chief sources of these phosphates are the river and land phosphates of South Carolina, the "soft," "pebble," and "rock" or "bowlder" phosphates of Florida, the "apatites" of Canada, the phosphate mines of Tennessee, and phosphatic slag,[1] a waste product from the manufacture of steel from phosphatic iron ores. With the exception of the latter, which is not an abundant product in this country, these phosphates are not yet used to any considerable extent, even when very finely ground[2] without having been treated with acid. They are however, the chief raw materials from which superphosphates are made.

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[1] Also known as Thomas Phosphate Powder, Thomas slag, and Odorless Phosphate.

[2] Finely ground mineral phosphate known as "floats" has been used to a limited extend in some localities.

Superphosphates, or soluble phosphates, are derived from the insoluble materials already described by first grinding to a powder and then mixing with sulphuric acid, which changes the insoluble phosphoric acid to the soluble form. The soluble phosphoric acid thus obtained is a definite chemical compound, and is identical in composition whatever may have been the material from which it was derived. The term superphosphates is, therefore, applied to any material containing soluble phosphoric acid as its chief constituent. In superphosphates there is nearly always present, however, in addition to the soluble, the reverted form, which is probable quite as useful as the soluble form. The superphosphates made from boneblack and bone ash differ from the mineral superphosphates mainly in showing a higher content of "available" phosphoric acid, an average of 16 per cent., which is practically all soluble. Mineral superphosphates contain on the average 14 per cent. of available which may include from 1 to 3 per cent. of reverted, besides more or less of the insoluble. Superphosphates made from animal bone differ from those made from the other materials mentioned in containing nitrogen in addition to phosphoric acid. They are, however, sometimes called "ammoniated superphosphates" or "dissolved ammoniated bone."

In the use of phosphoric acid, therefore, it must be remembered that the source has an important bearing in determining whether it is used as a phosphate or as a superphosphate. As regards the untreated phosphates, it must be remembered that those derived from organic substances, such as bone, are the more valuable because of their greater tendency to decay and greater ease of solution, and that this tendency to decay is promoted by such means as will increase the fineness of division. In the case of superphosphates, those which contain the greatest proportion of soluble phosphoric acid are relatively the most valuable, because the soluble phosphoric acid readily distributes itself in the soil and goes to the roots of plants, while the reverted remains where it is placed and the roots of the plants must come to it. In the next place, it should be remembered that phosphoric acid is not washed from the soil, though in a soluble form, since it is finally "fixed" by coming in contact with lime, iron, and other mineral substances usually present in good soils.

POTASH.

Potash may exist in a number of forms, though chiefly as chlorids, or muriates, in which case the potash is combined with chlorin; and as sulphates in which the potash is combined with sulphuric acid. With potash, however, the form does not exert so great an influence upon availability as is the case with nitrogen and phosphoric acid. All forms are freely soluble in water, and are believed to be nearly if not quite equally available as food. The form of the potash has, however, an important influence upon the quality of certain crops, due rather to the constituents with which the potash is associated than to the potash itself. For example, it has been demonstrated that the quality of tobacco, potatoes, and certain other crops is unfavourably influenced by the use of muriate of potash, while the same crops show a superior quality if materials free from chlorids have been used as the source of potash applied.

The chief sources of potash salts at the present time are the Stassfurt mines of Germany, and the products of these mines, which are

now readily obtainable in this country are kainit, sylvinit, muriate of potash, high-grade sulphate of potash, and double sulphate of potash and magnesia, or double manure salts. The kainit and sylvinit are crude products of the mines, and contain, in addition to potash, a number of other salts, chiefly ordinary salt (sodium chlorid) and magnesium sulphate. The potash in kainit, though in the form of a sulphate, produces an effect quite similar to that derived from the use of muriate, because of the large quantities of chlorids mixed with it. It contains on the average about 12½ per cent of actual potash. Sylvinit differs from kainit in containing a slightly higher per cent of potash, which exists both in the form of a sulphate and of a chlorid, and a lower content of the magnesia and other salts. The other potash products mentioned are manufactured from the crude forms, and are much more concentrated. The muriate and sulphate contain on the average about 50 per cent of actual potash. The chief impurity in the case of the muriate is common salt. The double sulphate of potash and magnesia contains about 26 per cent of actual potash, though much lower grades of this material are found.

Materials that do not show a wide variation in composition, and in which the constituents are practically uniform in their action, may be regarded as standard in the sense that they can be depended upon to furnish practically the same amount and form of the constituents wherever secured. For example, a ton of nitrate of soda or boneblack superphosphates (dissolved boneblack) will on the average furnish 320 pounds of nitrogen or of phosphoric acid, the nitrogen all in the form of a nitrate and the phosphoric acid practically all soluble; whereas a ton of tankage, for instance, will vary widely both in the content and in the availability of its nitrogen and phosphoric acid, depending upon the method by which it has been derived. Hence, nitrate of soda, sulphate of ammonia, dried blood, and superphosphates and potash salts are standard products, because they can be depended upon both in respect to the content and form of their constituents.

AGRICULTURAL V. COMMERCIAL VALUE OF FERTILIZERS.

The agricultural value of any of the fertilizing constituents is measured by the value of the increase of the crop produced by its use, and is, of course, a variable factor, depending upon (1) the availability of the constituent, and (2) the value of the crop produced. For example, in the first case, the agricultural value of a pound of soluble phosphoric acid is likely to be greater than that of a pound of insoluble when applied under the same conditions as to soil and crop, because in the one case the element is in its most available form, while in the other it is least available. In the second place, the soluble phosphoric acid may exert its full effect and cause a greatly increased yield on a certain crop, and still not cause an increase in value sufficient to pay the cost of the application, while for another crop the application may result in a very great increase in value. The character or form of the materials used must, therefore, be carefully considered in the use of manures. Slow-acting materials cannot be expected to give profitable returns, particularly upon quick-growing crops, nor expensive materials such profitable returns when used for crops of relatively low value as for crops of relatively high value.

This agricultural value is, however, separate and distinct from what

is termed "commercial value," or cost in market. This value is determined by market and trade conditions, as cost of production of the crude materials, methods of manipulation required, etc. Since there is no strict relation between agricultural and commercial or market value, it frequently happens that an element in its most available form, and under ordinary conditions of high agricultural value, costs less in market than the same element in less available forms and of a lower agricultural value. The cost of production in the one case is lower than in the other, though the returns in the field are far superior.

The commercial value has reference to the material as an article of commerce, hence commercial ratings of various fertilizers have reference to their relative cost and are used largely as a means by which the different materials may be compared.

VARIATIONS IN THE COMPOSITIONS OF MANUFACTURED FERTILIZERS.

All manufactured products or brands of fertilizers are made up of a mixture of the various kinds and forms of the fertilizing materials just described, and the differences that exist in the brands of different manufacturers are due both to differences in the character and to variations in the proportions of the materials used to form the different brands; that is, while all manufacturers must go to the sources of supply indicated, they may select either good or poor products and may vary the proportions of the different materials used.

The difference between a good brand of fertilizer and a poor one lies not so much in differences that may exist in the total amount of plant food contained in it as in the quality of the materials of which it is made. For instance, in one brand the nitrogen may have been derived entirely from insoluble organic materials and the phosphoric acid from untreated phosphates rather than superphosphates; while in another the nitrogen may have been derived from the three sources of nitrogen, viz., nitrates, ammonia salts, and organic matter, and the phosphoric acid entirely from superphosphates. In the first brand the total food contained may be quite as great as in the other, yet the immediate results obtained from its use would be less satisfactory than that obtained from the one containing the more active forms of fertilizing constituents.

The differences that exist between good and poor fertilizers are quite clearly shown by the chemical analyses made by the various experiment stations, provided the analysis is carried far enough to show both the amount and form of the nitrogen, phosphoric acid, and potash. For instance, an analysis which shows that a considerable proportion of the nitrogen exists as nitrates or as ammonia is positive evidence that good nitrogenous materials have been used; if it shows that the phosphoric acid is largely in a soluble form, the consumer knows that superphosphates have been used. On the other hand, if all the nitrogen is shown to be in the form of organic matter, and that a large proportion of the phosphoric acid is insoluble, it is evident that materials containing less active forms of plant food have been used. In the next place, it is the quality and amount of plant food that is contained in a fertilizer which determines its value rather than the relative proportion of the various constituents, though under certain well-known conditions the latter is of very considerable importance. Special crop brands are particularly useful only when an abundance of all the plant-food constituents are present in the soil.

THE PURCHASE OF FERTILIZERS.

As a rule, farmers are inclined to purchase fertilizers on the ton basis, without sufficient regard to the content or form of the constituents contained in them. The direct value of a fertilizer is determined by the percentage of nitrogen, phosphoric acid, or potash which it contains. Hence, the buying of a fertilizer is virtually the buying of one or more of these constituents. The more concentrated the material or the richer it is in plant food the less will be the expense of handling the constituent desired.

The following are illustrations of the methods by which brands may be made up, the differences that may exist in the content of actual fertilizing constituents, and the causes of variation in ton prices:

Formula No. 1.

Nitrate of soda	500lbs.,	furnishing nitrogen	80lbs., or 4 p. ct.
Boneblack superphosphate	1,100lbs.,	furnishing phosphoric acid	180lbs., or 9 p. ct.
Muriate of potash	400lbs.,	furnishing potash	200lbs., or 10 p. ct.
Total	2,000lbs.,	furnishing total plant food	460lbs.

Formula No. 2.

Nitrate of soda	250lbs.,	furnishing nitrogen	40lbs., or 2 p. ct.
Boneblack superphosphate	1,000lbs.,	furnishing phosphoric acid	160lbs., or 8 p. ct.
Muriate of potash	80lbs.,	furnishing potash	40lbs., or 2 p. ct.
Make-weight	670lbs.		
Total	2,000lbs.,	furnishing total plant food	240lbs.

Formula No. 1 shows a high-grade product, both in respect to quality of plant food and concentration, while No. 2 is high-grade only in respect to quality. In order that the plant food may be contained in 1 ton it is necessary to add what is called "make-weight," or a diluent, usually consisting of substances that contain no direct fertilizing value.

"High-grade mixtures cannot be made from low-grade materials. Low-grade mixtures cannot be made from high-grade materials without adding 'make-weight.' The advantages of high-grade products are concentration and high quality of plant food." [1]

It will be observed that formula No. 1 contains nearly twice as much plant food as No. 2; or, in other words, it will require about 2 tons of a fertilizer made according to formula No. 2 to secure the same total amount of plant food as is contained in 1 ton of No. 1. Now, the material in No. 2 other than the actual plant food is of no direct fertilizing value, but the actual cost of the constituents is considerably increased, because the expenses of handling, bagging, shipping, and selling are just double what they would be for No. 1.

It has been shown by continued studies at the New Jersey Experiment Station that the charges of the manufacturers and dealers for mixing, bagging, shipping, and other expenses are, on the average, $8.50 per ton; and also that the average manufactured fertilizer contains about 300 pounds of actual fertilizing constituents per ton. A careful study of the fertilizer trade indicates that these conditions are also practically true for other States in which large quantities of commercial fertilizers are used.

Formula No. 1 would contain 460 pounds of actual available fertiliz-

(1) First Principles of Agriculture, E. B. Voorhees, p. 109.

ing constituents per ton—160 pounds, or over 50 per cent, more than is contained in the average manufactured brand. That is, a farmer purchasing a brand similar to formula No. 1 would secure in 2 tons as much plant food as would be contained in 3 tons of the average manuafactured brand. Assuming that the charges per pound of plant food at the factory, and that the expense charges are the same in each case, and also that the quality of plant food in the one is as good as in the other, the consumer would save $8.50 by purchasing 2 tons of the former instead of 3 tons of the latter. In a few States the consumption of fertilizers ranges from 150,000 to over 300,000 tons annually, while in many it is from 25,000 to 50,000 tons.

Thus is shown the very great saving that may be effected in the matter of the purchase of fertilizers from the standpoint of concentration alone, or, in other words, the importance of a definite knowledge of what constitutes value in a fertilizer. This saving may be accomplished, too, without any detriment to the manufacturer, since the fdiference to him between making high-grade or low-grade goods, in reference to concentration, is largely a matter of unskilled labour. The manufacturers are in the business to cater to the demands of the trade; if consumers are intelligent, high-grade rather than low-grade goods will be provided by the manufacturers. Furthermore, as already indicated, high-grade in the matter of concentration means high-grade in quality, for high-grade mixtures can not be made from low-grade products.

In many cases, too, it is desirable to purchase the unmixed fertilizing materials, either for use singly or to be mixed at home. Here, too, a great saving may be effected—(1) in the cost per pound of the constituents, (2) in freight rates, and (3) in having the mixing performed by the ordinary labour of the farm at times when it does not interfere with regular out-door work. The advantages to be derived from this method are, however, fully realized only when it is possible to purchase in large quantities for cash.

As an illustration of the saving that may be effected, it is but necessary to cite the experience of a farmers' organization in New Jersey, which now purchases annually some 500 or 600 tons of unmixed goods. The cost per pound of the ingredients is to them over 40 per cent less than the average cost to those who buy the average mixture in small quantities "on time" from their local dealers.

It has been shown, too, by the studies of many of the experiment stations of both the East and South that the materials can be evenly mixed on the farm; besides, samples carefully taken show as good a mechanical condition as those made by the leading manufacturers.

This method of purchasing also possesses the further advantage of enabling the farmer to apply just the kind and form of ingredient that he has found by experience or experiment to be best adapted to his soil and crop. Besides, he knows positively, particularly in case of the element nitrogen, whether it is in the form of nitrate, ammonia, or organic matter, and whether the organic nitrogen is contained in substances that are likely to decay quickly, as blood, cotton-seed meal, etc., or in such insoluble and slow-acting substances as ground leather, horn, etc.

In mixtures the kind of organic nitrogenous substances used can not be definitely shown by a chemical analysis.

CONDITIONS UNDER WHICH FERTILIZERS MAY BE PROFITABLY USED.

With a more or less complete knowledge of the need of artificial supplies of fertilizer, the character, composition, and usefulness of the various materials, and the best method of purchase, the practical question arises, Will it pay to use them? Many of our most successful farmers are by their practice answering this question in the affirmative. It is, however, not entirely a question of plant food with them, and one phase of it may be illustrated by the following typical case: Mr. A applies fertilizer, his crop is doubled or tripled, and a reasonable profit is secured. Mr. B applies the same amount and kind under similar natural conditions of soil and receives no benefit. The diffierence in results is due not to the fertilizer, but to the farmer himself. In one case the natural agencies—sun, air, and water—were assisted and enabled to do their maximnm work, because care was taken to make the conditions other than the supply of plant food as perfect as possible, while in the other they were prevented from exercising their full influence because physical conditions of soil were imperfect, due to careless plowing, seeding, cultivation, and cropping.

In other words, the profit from the use of fertilizers is measured to a large degree by the perfection of soil conditions which are entirely within the power of the farmer to control. The production possible from a definite amount of plant food can be secured only when the conditions are such as to permit its proper solution, distribution, and retention by the soil.

The fact that fertilizers may now be easily secured and are easily applied has encouraged careless use rather than a thoughtful expenditure or perhaps an equivalent amount of money or energy in the proper preparation of the soil for them. Of course it does not follow that no returns are secured from plant food applied under unfavorable conditions, but it needs to be emphasized that full returns can not be obtained under such circumstances either with or without fertilizers. Good plant food is wasted and the profit possible to be derived is largely reduced. Moreover, farming in its strict sense is the conversion of three essential elements into salable products, and therefore the use of plant food must be governed largely by its cost, and the kind of crop upon which it is applied.

The very high prices paid by many for fertilizers—though admittedly due to their lack of knowledge concerning what constitutes value in a fertilizer and to irrational methods of buying—renders it impossible to secure a reasonable profit by their unsystematic use upon such staple products as wheat, corn, oats, cotton, and tobacco, because these crops absorb relatively large amounts of the manurial constituents, and are at the present time products of relatively low value.

The bushel or pound of crop contains a high content relatively of the fertilizing constituents while the selling price is low, thus leaving but a narrow margin between the cost of the constituent and the price received for it in the product.

The growth of such crops as potatoes, tomatoes, sweet potatoes forage crops for the dairy, and vegetable crops for the market or cannery by the use of high-priced plant food is more often attended with, profit, because they are usually crops of high market value and are

proportionately less exhaustive. This does not mean that the former crops shall be abandoned, but rather that our systems of practice shall be changed so as to include in the rotation some high-priced crop to which shall be applied such an abundance of plant food as to insure a yield, limited only by the season, and climate, which will, under average conditions of soil and season, yield a profit, besides leaving a residue of plant food for the cereals, grasses, or catch crops that follow. These being capable of extracting their mineral food from relatively insoluble scources will yield a large increase of crop without a direct outlay for fertilizers. Farming will thus be more successful, because profitable crops are secured, while at the same time fertility is increased.

THE KIND OF FERTILIZER TO USE.

The kind of fertilizer tc use should be considered (1) in reference to whether it shall be nitrogenous, phosphatic, or potassic in its character, and not to whose brand shall be used; and (2) as to the form in which the fertilizing constituents exist, whether quickly or slowly available. A proper understanding of these points requires that we shall consider briefly the various classes of farm crops and their power of acquiring food.

The cereals, Indian corn excepted (see p. 103), and grasses are quite similar in their habits of growth, and may be regarded as a class, distinguished by extensive root systems and long periods of growth which enable them to extract the mineral food necessary from relatively insoluble sources, and because of their very rapid development of leaf and stem during a short season just before maturity are unable to make normal growth during this period without an abundance of nitrogen in immediateley available forms. This period usually precedes the time of rapid nitrification; hence on soils of good natural fertility the application of nitrogen at the right time and in the form of a nitrate results in a largely increased crop. The fact here stated has led certain eminent scientists to regard nitrogen as a dominant or ruling element for this class of plants, and it is true if the limitations are properly understood.

The leguminous crops.—clover, peas, beans, vetches, etc.—should also be regarded as a distinct class. They possess powers of acquiring food which, as far as we know now, are not common to any other class of plants. They do not depend altogether upon soil sources for their nitrogen, but draw this element partly from the air, and they make almost ravenous use of the mineral constituents, particularly potash and lime. A knowledge of these facts is not only useful in indicating what kind of manures to use, viz., an abundance of the mineral constituents only, but suggests that the growth of these crops must result in the enrichment of soils in the expensive element, nitrogen, so essential for crops whose exclusive source of supply is the soil.

Root and tuber crops may also be regarded as a class which, because of their habits of growth, are unable to make ready use of the insoluble mineral constituents of the soil, and hence for full development require an abundance of all the fertilizing constituents in readily available forms. Of the three classes of fertilizing constituents, the nitrogen is especially useful for the slow-growing beets and mangels; soluble phosphates are required in abundance for the turnip; and potatoes,

white and sweet, respond favorably to liberal dressings of potash. That is, while the fertilizers should contain all three elements, certain of the crops, because of their peculiarities of growth, require certain of them in greater relative amounts and in immediately available forms.

The object of the growth, too, whether for the immature produce or for the fully developed plant, is a matter worthy of careful consideration. In other words, Shall the fertilizing be of such a character as to stimulate and force an unnatural and artificial growth, or such as assists in the natural development of the plant? That the specific function of nitrogenous manures is to encourage and even force leaf development is a fact not disputed by the highest authority; hence their use in stimulating unusual growth is of the greatest importance in growing market-garden crops, in order that the tenderness and succulence, which is the measure of quality in most of those products, may be secured.

Fruit Trees are slow-growing plants and therefore do not need quick-acting fertilizers as a rule. They appropriate plant food very slowly and highly soluble manures, such as nitrate of soda, are liable to be washed out of the soil without being utilized. For this reason the use of nitrate of soda is not advised except where the growth of nursery stock is to be forced or where bearing trees exhibit a lack of luxuriance in foliage. The old and still common practice of fertilizing fruit trees every few years with slowly decomposing manures, such as barnyard manure, leather waste, horn refuse, wool waste, leaf mold, tobacco stems, etc., is thus seen to have more or less of a scientific basis. Frequently, however, it is desirable to stimulate the growth and fruitfulness of the trees, and for this purpose more active fertilizing materials than the above are needed. In selecting and mixing the latter the fact that fruits are "potash feeders" should be taken into consideration.

Probably there is no better fertilizer for fruit tres than a mixture of muriate of potash and ground bone (1 part of the former to 1½ parts, of the latter). A good practice is to apply this mixture to clover or some other leguminous crop which is turned under as a green manure, and in addition, where tobacco stems can be obtained cheaply, to apply these about the trees. Wood ashes or cotton-hull ashes may be substituted for muriate of potash if these products can be obtained at reasonable prices.

The fertilizer requirements of small fruits are similar to those of orchard fruits, but being as a rule more rapid growers they can utilize to advantage heavier applications of soluble fertilizing materials and do not derive the same benefit as orchard fruits from slowly decomposing manures.

In deciding upon the kind of manure to use the character of the soil must, of course, be taken into account. Crops grown on soils poor in decaying vegetable matter (humus) are as a rule benefited by applications of nitrogenous manures, while those grown upon soils well supplied with this substance are more benefited by phosphates and potash. Upon heavy soils phosphates are likely to be more beneficial than nitrogen, while the reverse is the case on light dry soil. All sandy soils are as a rule deficient in potash, while clayey soils contain this element in larger quantities.

In this discussion the barest outlines have been drawn. There are many exceptions to the general rules. The farmer, with the general principles well in mind, must use his intelligence in applying them to his conditions.

FERTILIZERS SHOULD BE APPLIED SYSTEMATICALLY.

The suggestions already given lead to another of great importance, viz, that the use of fertilizers should be systematic. In order that this may be accomplished, a definite system of cropping should be adopted and a definite scheme of manuring worked out that shall meet the conditions of crop, season, and climate, and enable the farmer to utilize to the best advantage home and local supplies of manure. While it is impossible to give more than the merest outline of such methods, the following suggestions are offered:

In the first place, in nearly every State or even locality some one system of cropping is better adapted to the conditions than another.

It may be the extensive system, which includes large areas, and the crops, grain cotton, tobacco, or sugar cane; or the "intensive system," with smaller areas and crops of quicker growth and higher value. For the former a method of manuring should be adopted which is not too expensive, but which provides for increased crops and gradual gain in fertility. It would be impracticable in extensive farming, for example, to attempt to increase the yield of a wheat crop from 12 to 30 bushels per acre by the addition of fertilizers only, for as already pointed out, plant food is but one of the conditions of fertility, and if it were practicable from the standpoint of yield, it would be folly from the standpoint of profit.

A study of the following common four-year rotations—Indian corn, potatoes, wheat, and hay—will illustrate what is meant by rational and systematic methods of manuring. On soils of medium fertility spread the farm manure during the fall and winter, and after the land is ploughed apply broadcast and harrow in, or harrow first and then drill in, 400 pounds per acre of a mixture made of 100 pounds each of cotton-seed meal, ground bone, acid phosphate, and muriate of potash, or their equivalent in kind and form of other fertilizing constituents.

This mixture would have approximately the following composition: Nitrogen 2.5 per cent, phosphoric acid 10 per cent, and potash 12.5 per cent. If the land has not been previously manured, or if it is of a light sandy character, the proportion of nitrogenous matter should be increased and the application be heavier, say, from 600 to 800 pounds.

Corn makes its most rapid growth and development during the hot season, which is very favourable for rapid decay and consequent nitrification of organic substances in the soil. The nitrogenous manures, therefore, may be less in amount than for crops which develop rapidly earlier in the season, and for the same reason may consist of organic forms. The mineral constituents, particularly the phosphates, which the crop acquires less rapidly, because of its comparatively short season of growth, are applied in such forms and in such amounts as to provide for a largely increased crop, even though the seasonal conditions are not perfect.

For the potatoes, as a minimum application 650 pounds per acre of the following mixture may be used:

Fertilizer for potatoes.

	Pounds.
Nitriate of soda	50
Cotton-seed meal	150
Ground bone	100
Acid phosphate	200
Muriate or sulphate of potash	150

This mixture contains—nitrogen 3 per cent. phosphoric acid 8 per cent. and potash 12 per cent. In this application we are guided by certain other well-defined principles, chief of which are: This is usually the money crop of the rotation; we can therefore afford a more expensive manuring. Since it grows and matures in a comparatively short time, we need to furnish a reasonable excess of plant food in order that the crop may be abundantly supplied even though unfavourable conditions occur. It is a crop which is particularly benefited by potash, and we must therefore provide that element in largest proportion; and as it is not an exhaustive crop, we may expect considerable increase in soil fertility due to the unused residue.

After the potatoes are removed the land, on account of the frequent cultivation of the potato crop, is in fine mechanical condition essential for the rapid germination and early growth of wheat. It is also well supplied with plant food because of the manure applied to the previous crops in excess of their needs.

For the wheat, therefore, such home supplies of manure as are available may be applied after ploughing and well worked into the surface soil with the addition at time of seeding of 200 pounds per acre of dissolved bone, or a mixture of 100 pounds each of ground bone and acid phosphate. In spring, if the crop does not show a vigorous condition, sow broadcast 100 pounds per acre of nitrate of soda.

By this method the manuring is accomplished at a minimum expense, and the phosphates which are so essential for the proper development of the grain are provided, partly in an immediately available form partly in a form that will gradually decay and feed the crop at later stages of growth. The nitrogen is applied when the plant has greatest need for it and in a form immediately available, while for potash the plant depends entirely upon the accumulated soil supplies. The hay crop which follows, if it consists of clover, will be able to make normal growth with added supplies of phosphoric acid and potash only, which may consist of a mixture of equal parts of acid phosphate and muriate of potash at the minimum rate of 300 pounds per acre.

This method of fertilizing should not be changed from year to year, but followed in the succeeding rotation courses, and it will enable the farmer to secure an increased yield and improvement in soil at a minimum expense.

The principles involved may also be applied in other lines of farming, modified by character of soil, climate, and kind of crop. In market gardening the amounts applied should be proportionately increased,

and a larger proportion of the more active forms used, because in this case quick-growing crops which belong to the high-value class are produced. For fruit trees, which feed slowly and continuously, the mineral elements, as already explained, should be applied in greater amounts, and may be derived from the cheaper and more slowly available forms.

SUMMARY.

(1) Commercial fertilizers are mainly valuable because they furnish the elements—nitrogen, phosphoric acid, and potash—which serve as food, not as stimulants.

(2) The kind of farming in the past and the demands for special products in the present make their use necessary in profitable farming.

(3) In order to use them profitably the farmer should know—

(*a*) That nitrogen, phosphoric acid, and potash are the essential manurial constituents;

(*b*) That the agricultural value of these constituents depends largely upon their chemical form;

(*c*) That these forms are contained in specific products of a well-defined character and composition, and may be purchased as such from dealers and manufacturers and may be mixed successfully on the farm.

(4) The agricultural value of a fertilizer bears no strict relation to the commercial value; the one is determined by soil, crop, and climatic conditions, the other by market conditions.

(5) The variations in the composition and value of manufactured fertilizers which contain the three essential constituents are due to variations in the character and in the proportion of the materials used.

(6) The ton basis alone is not a safe guide in the purchase of these commercial fertilizers. Low ton prices mean either low content of good forms of plant food or the use of poorer forms. Fertilizers, high-grade both in quality and quantity of plant food, can not be purchased at a low price per ton.

(7) The best fertilizers can not exert their full effect on soils that are too dry or too wet, too compact or too porous. They can furnish but one of the conditions of fertility.

(8) The kind and amount to use should be determined by the value of the crop grown and its power of acquiring food.

(9) A definite system or plan should be adopted in their use; "hit or miss" methods are seldom satisfactory, and frequently very expensive.

Composition of the principal commercial fertilizing materials.

	Nitrogen.	Available phosphoric acid.	Insoluble phosphoric acid.	Total phosphoric acid.	Potash.	Chlorin.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*
1. Supplying nitrogen:						
Nitrate of soda ...	15. 5 to 16	...	...	...	...	...
Sulphate of ammonia ...	19 to 20.5	...	...	...	...	...
Dried blood (high grade)	12 to 14	...	...	...	...	...
Dried blood (low grade) ...	10 to 11	...	...	3 to 5	...	...
Concentrated tankage ...	11 to 12.5	...	...	1 to 2	...	...
Tankage (bone) ...	5 to 6	...	...	11 to 14	...	...
Dried fish scrap ...	7 to 9	...	...	6 to 8	...	...
Cotton-seed meal ...	6.5 to 7.5	...	...	1.5 to 2	2 to 3	...
Castor pomace ...	5 to 6	...	...	1 to 1.5	1 to 1.5	...
2. Supplying phosphoric acid:						
South Carolina rock phosphate ...	...	...	26 to 28	26 to 28	...	...
South Carolina rock superphosphate (dissolved South Carolina rock phosphate) ...	...	12 to 15	1 to 3	13 to 16	...	...
Florida land rock phosphate ...	...	...	33 to 35	33 to 35	...	...
Florida pebble phosphate	...	...	26 to 32	26 to 32	...	...
Florida superphosphate (dissolved Florida phosphate) ...	...	14 to 16	1 to 4	16 to 20	...	...
Boneblack ...	...	...	32 to 36	32 to 36	...	...
Boneblack superphosphate (dissolved boneblack) ...	...	15 to 17	1 to 2	17 to 18	...	...
Ground bone ...	2.5 to 4.5	5 to 8	15 to 17	20 to 25	...	...
Steamed bone ...	1.5 to 2.5	6 to 9	16 to 20	22 to 29	...	...
Dissolved bone ...	2 to 3	13 to 15	2 to 3	15 to 17	...	...
Thomas slag (1) ...	...	...	...	11.4 to 23	...	...
3. Supplying potash: ...						
Muriate of potash ...	...	...	...	...	50	45 to 48
Sulphate of potash (high grade) ...	...	...	...	...	48 to 52	5. to 1.5
Sulphate of potash and magnesia	...	...	...	...	26 to 30	1.5 to 2.5
Kainit ...	...	...	...	...	12 to 12.5	30 to 32
Sylvinit ...	...	...	...	...	16 to 20	42 to 46
Cotton-hull ashes (2) ...	...	...	...	7 to 9	20 to 30	...
Wood ashes (unleached) (2)	...	...	...	1 to 2	2 to 8	...
Wood ashes (leached) (2)	...	...	...	1 to 1.5	1 to 2	...
Tobacco stems ...	2 to 3	...	...	3 to 5...	5 to 8	...

(1) In good Thomas slag at least 80 per cent of the phosphoric acid should be soluble in ammonium citrate, i.e., available.

(2) Cotton-hull ashes contains about 10 per cent of lime, unleached wood ashes 30 to 35 per cent, and leached wood ashes 35 to 40 per cent.

COCCIDÆ, OR SCALE INSECTS.—X.

By T. D. A. Cockerell, Entomologist of the New Mexico Agricultural Experiment Station.

(*Continued from Bulletin, Nov., 1896.*)

Genus *Aulacaspis.*

(61.) *Aulacaspis boisduvalii, Signoret.* (Boisduval's Scale.)

Diagnosis—Female scale small, circular or nearly so, with the exuviæ nearly central. The scale is white or greyish-white, rather translucent, the exuviæ practically the same colour as the scale. Male scale white, linear, tricarinate, with straw-coloured exuviæ at one end. The young larvæ are pale yellow.

Distribution—Common in Kingston, Jamaica; also found by Dr. Sinclair near Montego Bay. In Barbadoes, on coconut; also in Trinidad, and recorded by Newstead from British Guiana. Found by Townsend at Alta Mira, Tamaulipas, Mexico. Also on hothouse and garden plants in Europe, the United States, New Zealand, South Australia and the Sandwich Is.

Food-plants.—Various palms and orchids, and sometimes other plants. It has been recorded specifically from coconut palm (Jamaica, Barbados), *Acacia* (New Zealand), *Livistona, Ravenala madagascariensis, Bromelia pinguin* (Mexico) *Latania commersoni* (Trinidad). Dr. Henderson found it in Kingston, Jamaica, on *Oncidium tetrapetalum* and *Broughtonia sanguinea,* in both cases associated with *Asterolecanium oncidii.* There used to be, and probably still is plenty of it on a coconut palm in the yard of the Institute of Jamaica.

Destructiveness.—Not a particularly destructive species, but sometimes it becomes abundant enough to call for remedial measures.

Note.—Mr. Morgan separated the form on coconut from near Montego Bay as a distinct species, *A. tentaculatus,* but I do not know any satisfactory character by which it can be distinguished. There is, however, a distinct species found on pineapples and *Bilbergia* in European and American hothouses, which is likely to turn up at any time in the West Indies. This is the *A. bromeliæ*; it may be known by the light yellow exuviæ being very much to the side of the scale, instead of in the middle.

Genus *Parlatoria.*

The female scales of this genus have the second skin of the exuviæ very large. Microscopic examination of the insect shows a peculiar abdominal fringe, not seen in any other West Indian genus, though it occurs in the European *Leucaspis* and *Syngenaspis.*

(62.) *Parlatoria* proteus *pergandii* var. *crotonis* Ckll. (The Croton Parlatoria.)

Diagnosis.—Small chaff-like scales on leaves of *croton,* white or brownish, the second skin pale reddish-brown, suffused with black in the middle. Male scale elongate, not carinate.

Distribution.—Discovered in the garden of the Museum at Kingston, Jamaica, in 1891. Since found by Dr. Freeland in Antigua, and by Dr. Berlese in the Botanic Garden at Padova, Italy.

Food-plants.—Only found on the ornamental varieties of *croton*; it occurs crowded near the midrib on the upper side of the leaf.

Destructiveness.—It may become troublesome if not attended to.

Note.—This is very probably a distinct species The typical *P. pergandii*, Comstock, infests orange trees in the Southern United States.

(63.) *Parlatoria proteus*, Curtis. (The Common Parlatoria.)

Diagnosis.—Similar to the last, pale grey-brown or brown, first skin more or less blackish, second a rather reddish brown varying to yellow, not suffused with black.

Distribution.—Found in Jamaica on a palm at Mr. Gardner's restaurant in Kingston, Feb. 22, 1892. It occurs also in other parts of the town. On various cultivated plants in Europe, and also in a hot-house in Washington City, U.S.A.; also, according to Maskell, on Apple in Queensland.

Food-plants.—Quite various, including palms, apple, *Microsamia, Selenipedium* and *Vanda.*

Destructiveness.—Its ability to live on very different plants makes it difficult to deal with, but it is not usually abundant enough to attract attention.

Genus *Pseudoparlatoria.*

In this genus the female scales might be taken for some *Aspidiotus* or *Diaspis,* while the male scales are something like female scales of *Parlatoria,* being oval in outline.

(64.) *Pseudoparlatoria ostreata,* Ckll. (Acalypha Scale.)

Diagnosis.—Small pale grey scales, covering the branches of *Acalypha* overlaping, looking under a lens like minute oyster-shells. Male scales on the leaves, along the mid-rib and principal veins.

Distribution.—As yet only known from Kingston, Jamaica, where it is common.

Food-plants.—Found especially on *Acalypha* in gardens, but also on *Solanum,* &c.

Destructiveness.—Very destructive to *Acalypha,* killing the branches it attacks.

Genus *Mytilaspis.* (The Mussel Scales.)

(65.) *Mytilapsis citracola,* Packard. (The Citrus Mussel Scale.)

Diagnosis.—A small brown scale shaped like a mussel shell, pointed at one end, rounded at the other,

Distribution.—Common in Jamaica; also found in Antigua, Montserrat, Bermuda, Trinidad, Florida, Louisiana, California, Tahiti, Sandwich Is., Fiji Is., Southern Europe, Ceylon, New Zealand, New South Wales, Queensland, South Australia (in hot houses), Victoria and in a hot house in Russia.

Food-plants.—The species of *Citrus*, and also *Murraya*. On June 25, 1892, Mr. C. B. Taylor brought me a twig of *Murraya* gathered in Kingston, with *M. citracola* and *Aspidiotus articulatus* upon it. Mr. Maskell reports it also from *Croton* and *Banksia integrifolia*. Green records it from *Cocculus indicus*, but probably the record relates to a distinct species, which he has since named *M. cocculi*. Mr. A. C. F. Morgan has expressed the opinion that *Mytilaspis pinnaeformis* of Bouché, found on *Cymbidium*, is identical with *M. citricola*, but the identity is very doubtful.

Destructiveness.—Quite injurious when abundant.

Parasites.—It is attacked by an undetermined hymenopterous parasite in Antigna. In Florida it has three parasites, *Aphycus flavus*, Howard, *Prospalta amantii*, Howard, and *Signiphora flavopalliata*, Ashmead.

Note.—*Mytilaspis gloveri* is another scale of *Citrus* trees found in Southern Europe, the Southern United States, &c.; it is known at once by its very narrow scale. It is curious that it does not occur in the West Indies; while at Tampico, Mexico, Prof. Townsend found it abundant, but no *M. citricola*.

(66.) *Mytilaspis crotonis*, Ckll.—(The croton Mussel scale.)

Diagnosis.—Small curled mussel-shaped scales on twigs of *croton*, so exactly the colour of the bark that they are very hard to detect, even when abundant.

Distribution.—Only known from Kingston, Jamaica, where it was discovered by Mr. J. J. Bowrey.

Food-plant.—A variegated *croton* with narrow leaves.

Destructiveness—It must be quite injurious, but it seems to be little distributed at present.

Parasites.—It has an undetermined parasite; a bright orange mite is also found praying upon the larvæ.

(67.) *Mytilaspis alba*, Ckll.—(The White Mussel scale.)

Diagnosis.—This differs from the other West Indian species of the genus by its white scale.—It could be taken for a *Chionaspis*, but the male scale is not keeled; it is linear, greyish-white, with the orange larval skin at one end.

Distribution.—Found in Kingston, Jamaica; a variety (var. *concolor*) is found in the Mesilla Valley, New Mexico.

Food-plants.—The typical form on a malvaceous weed with yellow flowers; the var. *concolor* on *Atriplex canescens*.

Destructiveness.—It is not known to attack any cultivated plant.

NOTE ON LECANIUM TESSELLATUM.

A study of material from other localities has brought out the fact that the form found in Jamaica on lignumvitæ attributed to *L. tessellatum*, is a distinct variety perhaps species. It is larger than the true *tessellatum*, and differs in various small details, for an account of which see Trans. American Entomological Society, Vol. XX. (1893) p. 51. I propose to call this lignumvitæ form var. *swainsonæ*, after Mrs. Swainson of Bath, who first collected it.—T. D. A. Cockerell.

RAMIE.

The Committee appointed by the Jamaica Agricultural Society to report upon the McDonald-Boyle machine and process for treating ramie stems presented the following report on the 17th July :—

Gentlemen.—At your last meeting you appointed a committee, consisting of Mr. T. H. Sharp and the Director of Public Gardens to witness a trial of the McDonald-Boyle machine and process for treating ramie stems. We attended a trial on 17th June, which lasted from 11.30 a.m. to 3.30 p.m.

Mr. Bernstein, the representative of the McDonald-Boyle Company was present and gave us the fullest information and every assistance in our task.

The machine is of very simple construction, consisting essentially of a revolving drum, armed outwards with transverse flanges, which strike the ramie stems against the lip of the feeding plate. A boy feeds three or four stems into the machine to about two-thirds of their length, and then reverses. The back action is required to finish the cleaning.

The power required to drive the machine is not great, and the inventors state that a six-horse power engine is all that is necessary for 40 of these machines. It worked as well with dry stalks as with green, and even when the stalks of different lengths and sizes were put through, the work was perfectly performed, though more slowly. There was no wood left on the ribbons, there was no fibre wasted, and the epidermis was so broken that it was completely cleaned off in the degumming process.

One boy fed the machine from a table where the ramie stems were placed and hung the ribbons on a rail on the other side. The fibre came out untangled and unbruised.

The following were the tests made: (1) 38½lbs. of stems. These were ripe stalks which had been cut between 3 and 5 p.m. by Mr. Moxsy, near Chapelton, on the 15th inst., so that they were dry. The bundle was said to have weighed 50lbs. when freshly cut. The stems were run through in 22 minutes and the wet ribbons weighed 8¼lbs. 15 ozs. of the wet ribbons were then taken and submitted to the degumming process. They were boiled in a chemical solution for an hour and a quarter, and for the next half hour were passed successfully through three baths of different chemicals, yielding 4½ ozs. of wet filasse. It was in a condition ready for combing and spinning and there was no loss in lustre or strength.

(2.) 4lbs. of mixed stems were put through the machine, 2lbs. being six weeks old, and 2lbs. 3 months old. They were supplied from Hope Gardens, and passed through in 2 minutes 50 seconds. The object of this test was to see how the machine would act if stems of different lengths and various ages were used mixed together. The work done was satisfactory, but it was evident that the best work is obtained if stems of the same age and thickness are used at the same time, especially as the machine can be adjusted to suit various thicknesses. Such adjustment would rarely in practice have to be made, and when necessary can quickly and easily be effected.

(3.) 12lbs. 14ozs. of stems from Hope Gardens, barely a quarter of an inch thick, were decorticated in 12 minutes, and yielded 2lbs. 4ozs. of ribbons. These had been grown in shade.

(4.) 28lbs. of ripe stems from Hope Gardens were passed through in 27 minutes and gave 4lbs. of ribbons.

(5.) 20½lbs. of stems yielded 3½lbs. of ribbons in 20 minutes.

The summary of these tests is:—

Test.	Weight of Stems.		Time in Minutes.	Weight of Ribbons, Wet.	
	lbs.	oz.		lbs.	oz.
1.	38	8	22	8	4
3.	12	14	12	2	4
4.	28	0	27	4	0
5.	20	8	20	3	8
Total	99	14	81	18	0

At a later test we were not present, but the Secretary and Assistant Secretary of the Society were in attendance, and 50lbs. of green stems yielded 12lbs of wet ribbons, which were degummed and gave 1lb. 11ozs. of dry filasse.

In the earlier tests many of the stems tapered to points less than a quarter of an inch; these were not completely cleaned and had to be removed. These points should be removed with the leaves in the field, a practice which would simplify the work of the labourers, give a better percentage in the yield of the machine and a better class of filasse.

As there is nothing to get out of order in this simple machine and no possibility of clogging, we do not see why the results on a large scale should not be quite as satisfactory as the tests to which we have submitted the machine.

We believe we can safely commend the machine to the earnest consideration of planters in Jamaica, but at the same time we think the whole process can only be operated successfully on a large scale by the central factory system.

W. Fawcett.
T. H. Sharp.

FERNS: SYNOPTICAL LIST—XLVI.

Synoptical List, with descriptions, of the Ferns and Fern-Allies of Jamaica. By G. S. JENMAN, *Superintendent Botanical Garden, Demerara.*

6. *Polypodium serrulatum*, Mett.—Rootstock slender, capillary with small, appressed pale linear scales stipites slender close or apart, 3 li. l. narrowly winged; fronds linear, stiff bright-green, naked, ½-1 li. w., 1-3 in. l. the lower part deeply serrated with open or subdistant sharp teeth, the upper entire, with the sides eventually reflexed or folded together; veins simple, spur-like, stiff, immersed, but prominent as are the slender filiform midribs; sori on the decurrent base of the veins of the upper part of the fronds, oblong or at length quite confluent, forming a linear costal band. Grammitis, Sw. Xiphopteris, Kaulf. Hook. Gard. Ferns. t. 44.

Common on decaying logs in coffee plantations and on trees in forest from the lower altitudes to the heighest peaks. The linear costal sori, which it ultimately presents, suggests affinity with *pleurogramme*, and to justify its generic separation, but the two following allied species clearly connect it with *Polypodium*. The slender filiform erect rootstock reaches 3 in. l. is often branched, and throws down prop-like wiry roots to the supporting surface. Casually an odd vein is forked. The pagina is often so little as to merely form a covering to the central rib and the spur-like veins along its sides.

7. *P. Jamesonii*, Jenm.—Stipites tufted from a slender shortly-elongated scaly rootstock, a line to ¾ in l. dark coloured and slightly ciliate; fronds 1½-3 in. l. 1½ li. w., stiff, bright green, glabrescent, puberulous on the midrib beneath; the apex pointed, the base tapering and decurrent, the upper ½ or ⅓ d subentire—serrulate, the lower part pinnatifid, with blunt oblong-deltoid open teeth, all ultimately deciduous leaving the naked filiform dark rachis; veins conspicuous, rigid close, simple, hardly reaching the edge, decurved at the base; sori short, basal on the veins, early confluent and covering the rachis.—*Xiphopteris* Hook. 2nd Cent. Ferns, t. 14.

Frequent on trees in forests at 6,000–7,000 ft. alt. but much less common than the preceding, with a rootstock similar in character, but stouter, shorter, and not uniformly vertical, and fronds two or three times as wide, the fertile entire portion usually remaining flat. The sori are at first oval, and quite distinct, but at length form a confluent band down the centre, but not reaching the margins.

8. *P. myosuroides*, Swartz.—Rootstock shortly ascending, clothed with small acuminate reticulated scales; stipites tufted, varying from hardly any clear to ½ in. l., puberulous or slightly ciliate; fronds 2-4 in. l., 1½-2 l. w., tapering at the base, as also, but less, to the apex, stiff dark green, glabrescent; pinnatifid throughout, but less deeply in the upper fertile portion; segments nearly deltoid, bluntish, adnate-decurrent, a line or less deep and half or two-thirds as w., reduced below to mere teeth, rachis dark coloured, slightly ciliate beneath; veins simple, not reaching the edge; sori oval, one to each lobe near the midrib, in the upper ½ or ⅔rds of the fronds, ultimately partially confluent. *P. retosum*, Mett. *Grammitis*, Sw. *Xiphopteris*, Klf.

Frequent on trees in forests on the highest ridges and peaks through the Blue Mountain range; hardly found below 6,000 ft. altitude. This has distinctly oval sori, which though partially confluent at last, never lose altogether their distinctness. The fronds are less deeply cut in the upper fertile portion, and the sori are borne at the base of the connected segments, not out in the lobe. This species shows the completed transition from characteristic Xiphopteris with its ducurrent sori into normal grammitis with separate oval sori.

9. *P. Sherringii*, Baker—Stipites densely tufted, short if any clear of the decurrent wings of the fronds, filiform, wiry and blackish; fronds 1½–2½ in. l., 2–2½ li. b., the apex blunt and terminated in a lobe, narrowed at the base; rather pale green, clothed with stiff scattered spreading brown hairs, opaque, stiff; cut nearly to the midrib into rounded, broadish decurrent lobes with an open oblique sinus between, showing a clear wing to the filiform flexuose rachis which is concealed in the pagina; sori solitary, terminal on the spur near the base of the short veins. Rare at 4,000–5,000 ft. altitude in the Port Royal mountains in the Newton district, on boughs of forest trees. This resembles *basi-attenuatum* in the entire rounded lobes, decurrent and dwindling at the base of the fronds, but is more densely tufted, with short stiff coriaceous fronds, which are much less ciliate. The fronds are erect or erecto-spreading and are so stiff that in course of time the pagina decays, leaving the rigid black midribs standing mixed with the growing fronds. The rootstock in the specimen before me forms an upright tuft of matted fibres nearly finger thick.

10. *P. nimbatum*, Jenm.—Stipites densely tufted, short or hardly any clear; fronds erect or erecto-spreading, 2 - 3 in. l. 1½ - 2 li. b., linear, narrowed at the base, the apex bluntish pointed, deeply pinnatifid; segments close, rounded, entire, ¾ - nearly 1 li. d. and b., broadly adnate and confluent at the base, opaque, coriaceous; a dull brownish green, villose with spreading hairs; rachis stiff, filiform, black, concealed in the pagina, which eventually drops from it; sori solitary at the base of the lobes on the spur of the short dark veins, the lurid brown hairs of the receptacles protruding.—Journ. Bot. 1886. p. 271.

Infrequent above 5,000 ft. alt. on trees in forests; most resembling *trichomanoides*. but smaller stiffer and more densely tufted, with close entire rounded shorter segments which are not lobulate, and villose, instead of scaly rootstock. The vestiture of young fronds has a lurid reddish tinge, and are yellowish green.

11. *P. exiguum*, Griseb. (not Heward).–Rootstock slender, erect, fibrous and scaly; stipites tufted, blackish, filiform, very short; fronds ¾-2 in. l. 1-1½ li. b., narrowed and decurrent at the base, the apex terminating in a small lobe, naked, membranous, pellucid, clear green, cut deeply throughout into blunt or pointed, ovate-oblong alternate segments, which are fully adnate and decurrent at the base, up-curved on the underside, with a small lobe or crenature within the hallow on the upper, ½-¾ li. d. less b.; rachis stiff, but filiform, black, very flexuose, stiff; veins simple in the barren, but with a short spur in the fertile segments, not reaching the edge, blackish; sori solitary terminal on the anterior branch, near the base of both lobe and segment.

Abundant on the highest ridges and peaks, to which it is confined, clothing in large masses the trunks of trees. A very pretty, distinct

little plant, with a thread-like flexuose rachis, the hollows in the sinuosities of which form the open sinuses between the lobes. The barren segments have no crenatures, and the vein is simple and falls unusually much short of the margin. Though decurrent, the segments are not confluent, so that the fronds are fully pinnate. Heward's plant of this name is a small state of *P. serpens*, Swartz, which is common in the district of Manchester parish where he collected.

12. *P. trichomanoides*, Swartz.—Rootstock erect, 1-2 li thick, densely coated with bright pale scales; stipites tufted, very short, furnished with a few spreading hairs; fronds linear, 3–6 in. l. 2–3½ li w., light green, sparingly villose with long soft dark brown or reddish hairs; firm, stiffish, tapering usually to both ends; cut almost to the filiform immersed rachis into spreading blunt oblong segments, which are 1–1½ li. l and ½–¾ li. w., decurrent at the base, with an oblique rounded or acute sinus, and a space their own width, or less, between them, the upperside in the soriferous fronds expanded near the base into a distinct crenature or lobule, lower ones dwindling to mere teeth almost or quite to the base of the stipites, veins obscure, one to each segment, not reaching the edge, forked or producing a spur in the basal lobule which bears the sorus.

Common from 5,000 ft. to the highest alts., growing chiefly on trees. The habit is erect and strict in short plants, but spreading shuttlecock-like in the taller ones; the segments are half as long again as wide, oblong in some cases, in others almost quarter oval, and open between. From the species near it, the lobule on the upper side of the segments uniformly and clearly distinguishes it.

13. *P. basi-attenuatum*, Jenm. n. sp. Stipites tufted from a small erect scaly and fibrous rootstock, short if any clear of the attenuated decurrent wings of the fronds, slender, and freely villose; fronds spreading or subpendent, soft pale coloured, and clothed with copious long, soft, spreading silky reddish brown hairs, 3-6 in. l. 2-4 li. w., the apex blunt and almost to the slender immersed rachis into oblong entire rounded oblique segments, which are close in the greater part, but at the much tapering base lax or subdistant, 1–2 li. l. ¾–1 li. b., adnate, decurrent and confluent at the base; veins not reaching the edge, bearing solitary sori near the base on the short anterior branch.

Common above 5,000 ft. altitude on the branches of trees; a much softer plant than any of its allies from which it is further distinguished by its weaker habit, characteristically attenuated base of the fronds, the oblong broadly rounded, unlobed segments, lying obliquely side by side, so close that the base of each is not expanded; the longer softer surface-hairs, which glisten in sunlight with a beautiful reddish fulvous hue and the usually larger sori. Hitherto ascribed to the mainland *P. truncicola*, Klotzsch, a stiffly erect species with deltoid segments, set horizontally like the teeth of a saw, but possessing the same beautiful soft silky vestiture.

14. P. *tæniifolium*, Jenm. n.sp.–Rootstock fibrous, erect, stipites tufted, several, ¼–½ in l., pilose with spreading dark brown hairs; fronds firm in substance, strict, pellucid, dark green linear, 4–7 in l. 2–3 li. w., gradually reduced at the base pinnatifid to the slender black thread-like rachis; surfaces especially the margins clothed with spreading dark brown hairs; segments oblong rounder, ½–¾ li. l., ½ li. w. close,

horizontal and connected by the adnate bases, even-margined and quite or nearly equilateral; veins pellucidly clavate, not excurrent, and with a short fertile spur at the base which bears the round solitary sori forming a line on each side of the rachis; the sporangia mixed with dark brown hairs.

This is intermediate between *trichomanoides* and *rigescens*. It is a stiffer plant than the former, darker in colour, though the substance is pellucid shewing the veins clearly. The segments, of which there are 70–100 to a side, are close, quite horizontal, rounded, and not dilated or lobuled on the upper margin. On the upper surface there is a dark spot over the end of both the main vein and the soriferous spur. The sori are dark as is also the spreading vestiture of hairs. Found by Mr. Syme some years ago at or near Mt. Moses, St. Andrew, 2,000-3,000 ft. alt.

15. *P. nutatum*, Jenm.–Rootstock very small and short, clothed with rather squarrose reticulated scales; stipites tufted, filiform, erect, dark, slightly ciliate or naked, $\frac{1}{2}$–$\frac{3}{4}$ in. l.; fronds erect, linear, tapering both to the apex and base, naked, or the margins and rachis beneath slightly ciliate, dark or brownish green, paler beneath; 3–5 in. l. $1\frac{1}{2}$–2 li. w., pinnatifid almost to the stiffish filiform immersed rachis; segments obliquely deltoid-oblong, close but shortly decurrent, $\frac{3}{4}$—1 li. l. less w. blunt; veins simple in the lobes, not reaching the point; sori solitary, oblong or rather elongate oblong, depressed; receptacles sunk, causing a superficial ridge on the upper surface.—Journ. Bot. 1886. 272.

Rare in forests on trees at 6,000 ft. alt. A very slender species, marked by its simple veins, obliquely oblong-deltoid, rather decurrent, segments, immersed grammitoid sori and narrow tapering form of the fronds. It is a narrower species than the next, both being very close allies. Of late years they have both been gathered on other of the West India Islands.

16. *P. Hartii*, Jenm.—Rootstock very short and small, clothed with dark brown reticulated scales, stipites tufted, few, slender, from hardly any clear to 4 li. l.; fronds erect, linear, tapering both to apex and base, stiff and coriaceous, slightly ciliate on the margins, or naked, dark green, paler beneath, 3-5 in. l. 2-3 li. w., cut almost to the membrane-covered dark filiform rachis into close, round-ended oblong, obliquely adnate segments $\frac{1}{3}$-$\frac{1}{2}$ li. w. 1-$1\frac{1}{2}$ li. l, basal one deltoid; a simple vein in each not reaching the apex; bearing elongated solitary sori sunk in a cavity which forms a ridge on the upperside of the segments, the sides of which are reflexed.—Journ Bot. 1886. 272.

Rare in forests at 6,000 ft. alt. on trees. The fronds are stiff and erect, though very slender, very much tapered at the top, the segments very numerous, oblong or rather linear-oblong and of equal width from the very little decurrent base to the rounded end. The veins are quite simple, and the sori decurrent along them in the central part, equally short of both apex and base, sunk in a cavity that forms a keel on the upperside; the margins reflexed and convergent.

17. *P. moniliforme*, Lag.—Rootstock free-creeping, forming broad interlaced patches, thick as strong cord, densely coated with rather loose reticulated dark scales; stipites close or scattered, numerous, wiry, naked, slightly scabrous, dark brown, scariose margined above,

$1\frac{1}{2}$-2 in. l.; fronds 3-6 in. l. $2\frac{1}{2}$-$3\frac{1}{2}$ li. w., subcoriaceous, naked, glossy, the upperside dark green, the under pale or glaucous; the apex entire, the lower part slightly narrowed, cut throughout to the slender black rachis into wide shallow alternate rounded lobes which are close and fully adnate at the base, 2 li. w. and 1-$1\frac{1}{2}$ li. d.; veins 2-4, simple, hardly reaching the margin; sori 2-4 to each segment, dorsal on the veins.

P. subcrenatum, Hook. Icon. Fil. t. 719. *P. flabelliforme*, Swartz, *Jamesonia adnata*, Kze.

Abundant on boughs of trees on Blue Mountain and all the peaks above 6,000 ft. altitude. Well marked by the very free creeping rootstock, which interlaces so much that the scattered fronds form a well furnished mass, and the broad shallow segments, wider than deep, nearly half-round in shape, and that form a zigzag line from one side to the other of the frond intersected by the slightly flexuose wiry rachis. The absence of vestiture and the dorsal situation of the sori are also characteristic features.

18. *P. saxicolum*, Baker.—Stipites few, tufted from a black, shortly-elongated, slender rootstock, erect, wiry, $\frac{1}{2}$-1 in. l., dark puberulous and clothed sparsely, with short spreading hairs, narrowly margined above; fronds erect, $2\frac{1}{2}$-$3\frac{1}{2}$ in. l. 3-5 l. b. subcoriaceous and stiff; dark green on the upper side, pale beneath; ciliate, chiefly on the thin sub-reflexed margins and the rachis; gradually narrowed both ways, pinnatifid virtually to the black thread-like rachis; segments alternate, entire, horizontal, oblong, or the lower and upper ones sub-deltoid, rounded, the base broad and fully adnate, barely confluent, $1\frac{1}{2}$-$2\frac{1}{2}$ li. l. 1-$1\frac{1}{2}$ li. b.; veins obscure, simple, short, 2-4 to a segment, reaching hardly more than half way to the edge; sori terminal, also 2-4, densely bristling with stiff dark brown hairs that are mixed with the sporangia.—Journ. Bot. 1877. p. 264.

Frequent in the moister parts of the forest on the slopes of the ridges and peaks at 6,000-7,000 ft. alt. generally growing on rocks, scattered in beds of moss, a plant here and there; less frequent on the branches of trees. When growing, the fronds have a bluish tinge on the upperside. Mostly it is found with one or two perfect fronds and two or three broken ones. Its nearest affinity is with *moniliforme*, but in this the pinnæ are deeper than broad, just the reverse of the rule in that, and their rootstocks are quite different, separating them remotely. The roots spread horizontally through the mossy surroundings and throw up young plants from them. The densely setiferous condition of the sori is a good distinguishing character. Gathered also at the same elevation in Guiana.

19. *P. albopunctatum*, Baker.—Stipites tufted from a slender shortly elongated black rootstock, $\frac{1}{4}$-$\frac{1}{2}$ in. l., filiform, dark ciliate; fronds ligulate, membranous, pellucid; thinly ciliate, chiefly beneath and on the rachis and margins, pallid green; 2-5 in. l. $\frac{1}{4}$-$\frac{1}{2}$ in. b., reduced at the base; cut to the filiform black flexuose rachis into close horizontal oblong or rarely roundish segments, which are $1\frac{1}{2}$-3 li. l. 1-$1\frac{1}{2}$ li. b., adnate-decurrent at the base, often slightly constructed on the upper side and rounded at the point; margins even or serrulate-repand; veins simple, much short of the margin, often only spur-like, with the dark brown sori terminal upon them, 1-3 to a side, the midveins often also

with a terminal sorus, upperside sprinkled with crustaceous dots situated over the sori.—Journ. Bot. 1877. P. 265.

Frequent and plentiful on trees above 6,000 ft. altitude along the higher ridges, forming large patches on the trunks of trees. The pinnæ are deciduous, leaving the hair-like rachises, which are persistent and durable and freely interlaced, on the plants. This feature and the white silvery dots on the upper surface, are good characters to recognise the species by.— Endemic.

20. *P. Jubæforme,* Kaulf.—Rootstock slender short erect, clothed with a few acuminate, minute, reticulated scales; stipites tufted, very short or hardly any clear of the decurrent membrane; fronds 4-9 in. l. $\frac{1}{4}$-$\frac{1}{2}$ w. firm but moderately thin and pellucid, naked, light green; tapering both ways, fully pinnate. Segments close, 1 li. w. 2-3 li. b. entire or the fertile slightly sinuate, linear-oblong, blunt or acute, adnate-decurrent at the base, with a close oblique sinus between them; rachis black, filiform, nearly or quite naked; veins simple, evident, falling short of the edge. Sori terminal confined to the outer half or two-thirds of the lobes, immersed, the opposite side papillose.

Gathered by Swartz whose spicimen is in the British Museum; but collectors since have not rediscovered it. Griesbach united it with *pendulum,* which it somewhat resembles, but is much smaller. The narrow-tapering character of the fronds, with no distinct terminal lobe; firm but thin texture naked surfaces, sori confined to the outer part of the segments, where it becomes confluent, and the skeletonised scales of the rookstock, sufficiently distinguished it. A very common tropical American species. P. parvulum seems to be the Swartzian name, and if so has priority, though applied since by Blume to an East Indian species.

21. *P. rigescens,* Bory.—Rootstock elongated, short-creeping or suberect the scales linear-acuminate, dark, reticulated; stipites tufted or apart, stiff, blackish, 1-1$\frac{1}{2}$ in. l. hispid-pilose with black spreading hairs; fronds 6-10 in. l. $\frac{1}{2}$-$\frac{3}{4}$ in. w. linear-lanceolate, rigid, erect but usually curved, dark brownish-black, green above, paler beneath, tapering equally to apex and base, terminating above with a caudate entire point; coriaceous and opaque; naked except among the capsules and on the rigid black rachis, which latter is clothed like the stipites but least in degree or at length naked above; cut almost or quite to the rachis into close oblong round-ended segments which are $\frac{1}{4}$-$\frac{1}{2}$ in. l. and 1-1$\frac{1}{2}$ li. w., straight, entire the base obliquely or subequally adnate and little dilated, lower ones dwindling to less than a line deep, but not separated, and more rounded than deltoid; veins obscure, simple, reaching the margin, capsules mixed with bristling dark hispid hairs; sori dorsal, medial, 4-6 to a side, reaching from the bottom to the top of the segment, the lower third of the frond barren.—Hook. & Grev. Icon. Fil. t. 216.

Frequent on the branches of trees above 5000 ft. altitude; among the most rigid of all this miscellaneous group of species; uniformly found growing on the branches of trees of the high ridges to which the distribution is confined, not on the trunks as most of the other similar species do. As in some other species, the specimens stain the mounting paper a deep green, leaving a distinct impressson permamanent when dry. The margins are reflexed, and there are casually

a few scattered hairs on the midribs. Eventually the segments are deciduous leaving the stiff slender rachises

22. *P. heterotrichum,* Baker.—Rootstock small fibrous; stipites tufted, very numerous, less than an in. l. slender, wiry clothed with long soft spreading hairs; fronds pendent and over-lapping, flaccid, dull gray-or rusty-green ; 3-8 ins. l. ½-¾ in. b. ligulate, or oblong-ligulate, little reduced at the base, quite pinnate; segments numerous close, spreading, obliquely, adnate or decurrent at the base, linear-oblong, blunt or pointed, 1 li. w. ¼-½ in. l entire or rarely serrulato-dentate, the upper margin often with a slight curve; rachis filiform, black, and with both surfaces puberulous-glandulose, and rusty-ciliate with soft spreading hairs ; veins short, simple, oblique, reaching halfway or more to the margin ; sori copious, dorsal or terminal, close, in two contiguous rows near the midrib, 4-7 to a side.—Journ. Bot. 1879 p. 262.

Frequent on trees in forest about the highest peaks at 7,000 ft. alt. ; gathered on Blue Mountain and John Crow peaks ; intermediate between *cultratum* and *capillare*. From the latter its hairy surface at sight distinguishes it, and from the former, the smaller size, close narrow pointed segments, which are fully adnate, though sometimes a little narrowed and not rounded or auricled at the base on the upperside, and the copious close brown sori. In the mature fronds the pinnæ of the lower half or third are usually dead and dry.

23. *P. pendulum,* Swartz.—Root-stock small or shortly repent and elongated, clothed with reticulated conspicuously ciliated scales; stipite tufted, very short, if any clear of the decurrent wings, black and gray with stellate puberulæ; fronds pendant, ½-1 ft; l. ½-1 in. w., subcoriaceous, copiously pellucid-dotted, glabrous, bright, pale, brown-green, glossy tapering to the attenuated base and less so to the short entire pointed apex, pinnatifid nearly to the rachis; segments spreading entire ¼-½ in. l., 1½ 2 li.b., obtuse-acute pointed, dilated and broadly adnate and confluent at the base, with an open rounded sinus between that is once or twice their own width, the reduced lower ones triangular ; rachis filiform, black beneath, above covered by the pagina, rather flexuose ; veins and ribs raised on the upperside, the former short, not reaching the margin, the apices thickened and glandulose above ; sori 2-6 to a side, close to the midvein, on a very short basal spur, sunk the opposite surface papillose just within the glands of the veinlets.

Infrequent on trunks of trees in forest at 6,000 ft. altitude. In the the larger states which sometimes reach 1½ ft. long, the segments are dilated nearly though not quite equally at the base on both sides, and are therefore only hardly more decurrent than surcurrent. The species is well marked by the freely ciliated light-coloured scales of the rootstock, papillose glandulose surface, and sori lateral near the base of the veins. It varies in colour from dark to rather yellowish-green, and is always clear and bright. Some creature seems to feed on the fronds, for out of possibly, a hundred, gathered over a series of years, only one is entire.

24. *P. lasiolepis,* Malt.—Rootstock shortly-repent 2-3 l thick, densely clothed with dark-brown reticulated and ciliate scales ; stipites subtufted, cilate with spreading hair strong, dark coloured, from hardly any to 1 in. l. ; fronds 6-9 in. l. ¾-⅞ths in. w. firm, ciliate, especially on the rachis and margins dark or light clear brown-green ; pinnatifid

nearly to the rachis, passing at the apex rather abruptly into a sub-entire point, gradually reduced at the base through rather deltoid to rounded broad and shallow scallop-shaped lobes which are connected and form a wing to the stipites; segments oblong, obtuse-pointed, broadened to the base where they are close, obliquely adnate and connected, 4-6 li. l. 1½-2 li. b.; rachis thread-like, bnt rather strong, a little flexuose or not, veins simple, reaching halfway to the margin, with the sori terminal upon them

Infrequent at 4,000-5,000 ft alt. on trees in forest gathered at Vinegar Hill and elsewhere. This comes nearest perhaps to *pendulum*, from which it differs by the stronger rootstock, close more decurrently adnate segments hairy surface, terminal superficial sori, and absence of glands, and different apex and base. It is also erect in growth, and the veins and midribs of the pinnæ are not raised on the upperside.

25. *P. cultratum*, Willd.—Stipites numerous, tufted, slender ½-1 in. l. or rather more clothed with long soft reddish or rusty silky hairs as is also the small fibrous rootstock: fronds pendent, flaccid, ½-1 ft. l. by ¾-1½ in. w., rusty with copious soft spreading hairs, membranous, pellucid; fully pinnate, shortly reduced at both base and apex; pinnæ very nmerous, horizontal, close or somewhat apart, lanceolate-oblong, ¼-¾ in. l. 1½-2 li. w. the end rounded, both the upper and under sides of the fully adnate base slightly decurved, margins entire and even; rachis black, filiform, villose; veins simple, short reaching about halfway to the margins, 6-8 to a side, with the round sori, which are not very close, terminal on their ends forming a medial series; midveins flexuose, often or usually fertile at their extremity; sporangia copiously mixed with rusty hairs.—Pl. Fil. t. 88 (much too large).

var. *a. elasticum.*—Fronds linear-ligulate nearly or quite sessile, shortly or at considerable length reduced at the base, often little, if at all so at the the top, uniform or variable in width throughout, ⅓rd.-1½ ft. l. ¼ to 1 in. w., segments close fully adnate at the base, 2-6 li. l 1-2 li. w., the upper margin curved or decurved, even; veins 2-6 to a side; texture delicately thin: sori usually 3-6, on the outer veins.—*P. elasticum*, Bory.

var. *b. brachyphyllum, Gr.*—Fronds 4-12 in. l. ¾ to over 1 in. w. segments oblong ovate or lanceolate oblong, varying from close to nearly their own width apart, ¼-⅔ rds. in. l. 1½-2 li. b. rounded or subauricled on the upperside of the base and more or less free there, margins even or crenate; veins sori and texture as in the type.

var. *c. heterophyllum.*—Segments lanceolate-oblong, crenate or lobate, often transformed into pinnate pinnæ, which resemble the normal fronds.

Abundant, draping the trunks of trees, in forests above 4,000 or 5,000 ft. altitude; one of the commonest of the epiphytal species of the great forest region, well distinguished by its soft flaccid membrano-elastic texture and soft copious vestiture of reddish or fulvous hairs. In nearly all the forms there is more or less of a distinct curvature of the upper margin from the base outwards. The type is marked by the segments being fully adnate at the base, the upperside not at all auricled or partially free. ' *A* is mostly though not uninformly a smaller delicate-textured state, of narrower width sometimes much attenuated at the base, with shorter segments, which are often fertile only in

outer half. *B* is the commonest of all and very variable. It is best recognised by its usually more open segments which show a tendency more or less developed to form an auricle and become free of the rachis on the upper (and sometimes the under) side. They resemble in shape those of *Asplenium parvulum.* *C* is a variety of the last in which the pinnæ are lobed, or changed entirely into frond-like branches from 1 to 4 in. l. ½-⅔ rd. in. w. making the fronds as broad as long.

26. *P. capillare, Desv.*—Stipites tufted from an erect fibrous ciliate scaly and villose rootstock, winged to the base or nearly so by the decurrent sides of the fronds, deciduously villose, wiry and dark coloured; fronds prostrate or pendent, 3-10 in. l. ½-1 or 3 in. w., shortly reduced at the base, nearly or quite pinnate throughout chartaceous, pellucid, naked or slightly puberulous-glandulose, pale green and rather glossy on the upperside; segments close linear, adnate-decurrent, the point acute ½-1 or 2 in. l. about 1 li. more or less w. with an oblique open or acute sinus between; margins more or less conspicuously sinuate, rarely distinctly toothed; rachis black, filiform; veins simple (rarely forked) very oblique, not reaching the margin, midveins flexuose; sori terminal, separate, slightly sunk or superficial. P. *decipiens,* Hook. Sp. Fil. vol. 4. t. 279. B.

Frequent on trees in the forests round the summits of the highest peaks at 7,000 ft. altitude. It varies a good deal in size and the larger and smaller states look very different. It is best distinguished from graveolens by the more distinctly sinuate pinnæ, the margin being expanded where the sori occur and contracted between, which in the smaller plants gives quite a crinkled aspect. It is also destitute of the strong scent of that species, and occupies a higher elevation. The pinnæ sometimes are transformed into elongated pinnate frond-like branches, 2-3 in. l. as in *cultratum.*

27. *P. graveolens,* Baker.—Rootstock fibrous, densely clothed with small brown ciliate scales and soft reddish spreading tomentum, upright, nearly pencil-thick; stipites densely tufted, wiry, clothed like the rootstock, ½-2 in. l.; fronds prostrate or pendent, ½-1 ft. l. 1-2 or 3 in. w., little or hardly reduced at the base, the apex often terminating in a long linear sinuate or lobate caudate segment, fully pinnate throughout or nearly so to the thread-like rachis, chartaceous, pellucid, puberulous, often with granular dust beneath, pale green, glossy above; pinnæ linear, acute or obtuse, faintly crenulate-repand, spreading or erecto-spreading 1-1½ or 2 in. l. about 1 li. more or less w., equal or unequal in length, adnate-decurrent at the base with an oblique rounded sinus and open space 1-4 times their own width between; veins very oblique, simple or forked, not reaching the edge; sori terminal, about an ⅛th in. apart alternate or subopposite in contiguous rows.—Journ. Bot. 1877. P. 265.

Abundant on trees in the forest clothing the ridges at 5,000-6,000 ft. altitude. Less variable in size than *capillare,* more constantly uniform in habit, the pinnæ more even in the margins, and much more open between, and the rootstock more densely villose, the bright coloured scales being concealed thinly. Most strongly scented with a perfume that apparently loses none of its fragrance with lapse of time. The veins are so oblique as to run nearly parallel with the midrib.

28. *P. curvatum*, Swartz.—Stipites tufted from a fibrous finely scaly erect rootstock, short, flattish, winged to the base; fronds pendent, 9-18, or more in l. 1½-4 in. w. coriaceous and brittle; glabrescent, or puberulous with white granular dust. pale or dark green above, grayish beneath; reduced at the base, pinnatifid nearly to the flat completely immersed rachis; pinnæ spreading, linear usually rather unequal in length, 1-2 in l. 2-3 li. w. at the dilated obliquely adnate confluent base, tapering outwards to the usually obtuse point, with an acute or rather open sinus between; margins entire or slightly sinuate-repand, thin; veins usually forked, both branches a little short of the margins; sori round or oval, terminal on the anterior limb, about ⅛th in. apart in a long marginal row on each side.—*P inæquale*, Fée, Fil. Ant. t. 12.

A Fronds ¾ in. w. linear, uniform in width throughout, ½-1½ ft. l. segments oblong, blunt, close, with the sori usually in the outer part.

Common in the forest above 5,000 ft altitude on trees. A peculiar species, showing no close affinity with any local species, of a gray leathery appearance, very brittle, and the whole vascular ramification, including stipe and rachis, concealed under the parenchyma, as in some of the smaller species. *A* is found in Coffee fields on decaying logs at 2,500 ft. altitude: gathered at Murray's flat Mt. Moses. The fronds are uniformly linear reaching 1½ ft. or more long, the inner half or more being dead and brown in the longer ones. This is near *P. Pearei*, Baker.

29. *P. Ottites*. Swartz.—Rootstock fleshy, repent, as thick as a quill or less, densely clothed with bright reticulated scales, which are mixed with tomentum; stipites erect, serial, apart, but often contiguous, 1-2½ in. l., dark, slightly ciliate or naked, faintly margined above; fronds erect, 4-9 in. l. ¾-1½ in. b, little or hardly reduced at the very base, the apex terminating in a sinuate subentire segment, pinnate, elastico-membranaceous glabrescent, dark or brownish-green, pinnæ spreading or erecto-spreading, ½-1 in. l. 1-1½ li. b., entire or crenate-sinate, linear-oblong, obtusely pointed, adnate decurrent to the slender, dark, stiffish, ciliate or glabrescent rachis, with a clear space once or twice their own width between, or narrowly confluent by a rounded oblique more or less open sinus; veins oblique, simple, or rarely furcate at the apices, terminating much short of the margin, midvein flexuose; sori terminal, (on the anterior branch when the vein is forked), medial nearly ⅛ in. apart. Plum. Fil. t. 85. *P. tenuifolium*, H. B. K.

Infrequent on wet rocks in forests of Portland at about 2,000 ft. alt.; resembles *graveolens* and *capillare* somewhat in the pinnæ, but the texture is thinner and more elastical, and the rootstock quite different, with few stiff straight petioles and fronds. Only the basal pair of pinnæ are usually reduced..

30. *P. trifurcatum*, Linn.—Rootstock short-creeping, 2 or 3 l. thick, densely clothed with bright slightly ciliate-edged scales; stipites wiry, tufted, 3-5 in. l., dark, clothed thinly with spreading aureous hairs; fronds linear-lanceolate, densely pellucid-dotted, chartaceous, dark green, naked or slightly villose, especially on the margins, 5-10 in. l. ¾-1¼ in. w. or over, the base shortly cuneate, the apex obtuse and subentire, obliquely lobed ⅓rd or rather more to the slender flexuose covered rachis; lobes entire about ¼ in. w. and as much or less d., close,

rounded; veins pinnate in the lobes, the branches curved not reaching the margin, the opposite basal ones casually uniting; sori copious, nearly medial on each side of the flexuose primary veins, costal ones usually oblong and dorsal or terminal on the veinlets, those above these rounded and situated on a lateral spur.—Plum. Fil. t. 138. Hook and Grev. Icon. Fil. t. 54. *P. scolopendrioides*, Hook and Grev.

Infrequent on trees and rocks at 2,000-3,000 ft. alt. in the forests of Portland. The casually uniting veins might remove this to the other primary division, and the subentire state that some of the fronds are found in the first section of this, but it has obviously most relationship here, distinct and isolated though the type is from any of its allies. Confusion must be guarded against from the genus *Enterosora* which is exactly of the same size and form. Plumier's figure is a very good one but all the fronds are made trifurcate at the top.

31. *P. Eggersii*, Baker.—Rootstock short, rather slender, repent or erect; stipites tufted or subtufted, wiry, dark brown, erect, thickly clothed with spreading hairs; fronds 3-7 in. l. $\frac{2}{3}$rd-1 in. w. thin and elastic, pellucid, thinly ciliate, especially on the rachis and edges, and bright metallic green; terminated or not by a distinct segment, somewhat reduced at the base, pinnatifid throughout almost to the black thread-like rachis, which is not immersed; segments close, obliquely adnate, oblong rather rounded at the point, even-margined, 5-6 li. l. $1\frac{1}{2}$-2 li. w., with a sharp sinus between; veins few, simple or forked; sori nearer the midrib than margins on a short spur.—Hook. Icon. t. 1671.

Rare on trees in forest near Mt. Moses, 2,000-3,000 ft. alt., resembling in habit and size most *lasiolepis*. It has the texture of *suspensum* and *cultratum*, but is rather firmer, and in form is intermediate between the former and *brunneo-viride*, with the rather upright growth of the latter and metallic tinge in colour.

32. *P. suspensum*, Linn.—Rootstock creeping, elongated, densely coated with bright, rather soft, ciliated small scales; stipites 4-8 in. l. subtufted or apart, erecto-curving, slender, dark or blackish; varying from almost naked to pilose with soft rusty spreading hairs; fronds pendent, linear-lanceolate, $\frac{1}{2}$-$1\frac{1}{2}$ ft, l. $1\frac{1}{4}$-$1\frac{3}{4}$ in. w., flaccid, membrano-papyraceous, both surfaces and specially the margins more or less clothed with soft rusty spreading hairs, cut to the thread-like, blackish, often flexuose, rusty-ciliate rachis into close horizontal segments, $\frac{1}{2}$-nearly 1 in. l. 2-$2\frac{1}{2}$ li. w. which are oblong-lanceolate, and gradually narrowed outwards to an acute or bluntish point, the broadly adnate, equilateral, base sometimes dilated; veins simple not reaching the entire margin, sori dorsal, or terminal on a rudimentary lateral spur produced below the middle of the vein, the rows contiguous, nearer the midvein than margins,—Pl. Fil. t. 87. (dubious).

Common on trees above 5,000 ft. alt. in the eastern parishes and at 2,000 ft. in the woods of the western; larger in the latter. The stipites are erect but curved at the neck, so that the fronds, which are occasionally narrowed there, one or two pairs of the segments being reduced, hang pendent, over each other tapering by imperceptible graduation to the outer end.

33. *P. asplenifolium*, Linn.—Rootstock short, densely clothed with ciliated brown acuminated scales, stipites curved, more or less tufted, 6-8 in. l. wiry strict, dark brown, pilose villose with spreading brown hairs; fronds elastico-chartaceous fuscous-green, pubescent chiefly beneath and on the margins, pendent, $\frac{3}{4}$-$1\frac{1}{2}$ ft. l, 2-3 in. b. the base reduced, cut to the dark, exposed, pilose rachis into close horizontal segments, which are broadest at the sub-equilateral and fully adnate base, tapering thence to the rather bluntish point, 1-$1\frac{3}{4}$ in. l. $\frac{1}{4}$ in. w. even edged or faintly serrulate within; veins oblique, close; sori on a short anterior spur, round, contiguous, forming a medial row on each side the slender veinlike midrib of each segment.—Pl. Fil. t. 102. D.

A large and much stronger plant than *suspensum*, with close horizontal tapering pinnæ which are broadly adnate and widest at the base, with two rows of rather large circular medial sori. First gathered by Swartz. My description is taken from the specimens collected by Mr. Syme at Jones' Gap, which are quite identical with those from other countries in the Kew Herbarium. The segments are both shortly surcurrent and decurrent at the base, and with an open but sharply acute sinus, as in the larger states of *suspensum*, from which it is hardly distinct.

34. *P. brunneo-viride*, Baker.—Rootstock short or elongated, erect or decumbent, densely clothed with subulate dark brown ciliated scales; stipites tufted, 3-5 in. l., few, stiffly erect, dark castaneous or blackish, glossy, nearly or quite naked; fronds suberect, oblong-lanceolate, 4-9 in. l. 1-2 in. w., subcoriaceous, pellucid and dotted, naked or with a few inconspicuous hairs on the margins, dark-green above, pale beneath and tinged metallic brown, base truncate and not reduced, very gradually narrowed upwards to the subentire-pointed apex; cut almost to the black thread-like puberulous or slightly scurfy rachis into close oblong-lanceolate, spreading pointed obliquely adnate confluent entire even-margined segments which are $\frac{1}{2}$–1 in. l. and 1-3 li. b. at the base, from which they taper gradually to the point; veins forked, not reaching the edge sori copious, terminal on the shorter anterior branch, medial, a line or less apart to the rows:—Journ. Bot. 1877, p. 265.

Infrequent on trees in forest at 6,000-7,000 ft. alt. along the highest ridges. The lowest vein on the inferior side generally springs from the rachis, and the sori are often rather oblong or oval at first. It is perhaps, of local species, nearest *suspensum*, from which it is distinguished by its stiff subulate scales of the rootstock, bright peculiar, lurid colour, stiff erect habit, oblique pinnœ, forked veins and naked surfaces. It is one of the most beautiful of the high mountain tree Polypods.

35. *P. firmum*, Klotzsch.—Rootstock erect or suberect, often elongated, clothed with dark brown acuminate reticulated scales; stipites tufted 1-$1\frac{1}{2}$ in. l., stiff dark coloured puberulous and dark ciliate down the face, at length naked beneath, scariose or cartilaginous-margined; fronds lanceolate or oblong-lanceolate, stiff, erect, 5-8 in. l. $1\frac{1}{4}$-2 in. b. pinnate, reduced about equally to both ends, with a caudate, 1-2 in. l. subentire segment at the apex, toward which the lateral ones gradually dwindle, rigid, coriaceous, opaque, very dark green above, the reverse paler, naked except on the ribs beneath, and on both sides of the stiff

black hispid rachis; segments entire, even and revolute edged, stiff, linear, acute-pointed, spreading but rather up curved ½-1 in. l. 1-1½ li. b. fully adnate at the base and rather dilated more so on the upper than the inferior side, leaving an open space equal to their own width between the outer parts of the segments, the reduced basal ones small and deltoid; midveins distinct black and threadlike; the laterals obscure, simple, reaching the margins; sori dorsal, medial, 6-12 or more to a side; capsules not mixed with hairs.

In frequent on the branches of trees above reach from the ground at 6,000-7,000 ft. alt. in forests; this is intermediate between *rigescens* and *apiculatum*, resembling both but partaking more of the rigid habit of the former, from which it may be distinguished at sight by the broader fronds, linear open pinnæ which are only about half as many in number, the black midvein not concealed in the pagina, and the absence of hairs among the sporangia. It may be regarded as first of those pectinate species in which the midrib of the pinnæ is exposed.

36. *P. taxifolium.*—Linn.,—Rootstock creeping, short, or elongated and fasciculate, strong, clothed with dark brown linear acuminate scales; stipites tufted or sub-tufted, strong 3-6 in. l. and with rachis dark deciduously villous with spreading long tawny hairs which ultimately turn blackish; fronds lanceolate or oblong lanceolate, acuminate, ½-1¼ ft. l. 1½-3 in. w., reduced both ways, pinnate, subcoriaceous, pellucid; naked or with a few marginal hairs, the upper side glossy dark-green, the under pale and nearly glaucous; pinnæ linear, entire, even-edged, very numerous and close, spreading horizontally, straight, obtuse-pointed, 1-1½ in. l., 1½-2 li. b. adnate and equilateral at the base, the lower ones gradually reduced and shortly separated, dilated and (in the larger fronds) slightly auricled on each side; veins straight, oblique, conspicuous dark and raised beneath as is the threadlike midrib simple, not reaching the margins; sori submarginal, terminal, reaching from the base to the apex of the pinnæ, with frequently a crustaceous scale, one each on the upper side. *P. L'Herminieri* Fee Fil. Ant. t. 12.

Frequent on trees at 7000 ft. alt. on the highest ridges and peaks, plentiful on the higher slopes of Blue Mountain and other peaks; of the several species of the *pectinatum* group this is distinguished by its stiff texture, simple veins, andsubmarginal sori. The plant described by Grisebach under this name with "most veinlets 2-fid," seems to be the next species.

37. *P. Plumula*, H. B. K.—Rootstock strong, short-creeping, densely clothed with dark very fine scales; stipites sub-tufted, strong, erect, dark or ebeneous and rather glossy, 2-6 in. l., puberulous or naked, with faint marginal lines; fronds ½-1¼ ft. l. 1½-3 in. w., erecto-spreading oblong-lanceolate, acuminate somewhat reduced or not at the base, pinnate, pinnæ horizontal but often rather up-curved, very numerous and close, linear, acute or obtuse, rather dilated and fully adnate at the equal-sided or more often shortly surcurrent base, 1-1¾ in. l. 1½ li. w., the lower ones hardly, if any, more open than the rest, elastico-papyraceous, naked or glandulose-puberulous, with a few minute fugacious scales on the even margins and the ribs, dark green; rachis strong, dark or ebeneous and subglossy, glandulose and rusty-puberulous above a few minute deciduous scales beneath; veins obscure, immersed,

forked; sori copious, terminal on the short anterior branch, contiguous in two long bright yellow rows that occupy nearly all the space between the dark thread-like midrib and margins :— *P. elasticum*, Rich, Eat, Ferns N. Am. p. 63. *P. Pulchrum*, M, & G, *P. Schkuhri*, Raddi.

Common on open rocks and banks at nearly all elevations up to 5,000ft., alt. variable in size but well marked from its allies by its copious horizontal close and very narrow pinnæ, and long rows of conspicuous yellow sori. The substance is so elastical that in dry weather the fronds curl up, expanding again with rain. The sori do not reach quite to the rachis, so that there is a naked band down the centre of the frond, which in many cases gradually broadens toward the base. Pl. Fil. t. 89 (*P. Plumula*, Willd.) is either this or *taxifolium*.

38. *P. pectinatum*, Linn.—Rootstock strong, short-creeping, densely clothed with small dark-brown subulate scales; stipites contiguous and subtufted, or apart. strong or slender, usually dark coloured, puberulous or slightly ciliate, often slightly margined, rarely a span long; fronds 1-2 ft. l. 2-5 in. w. oblong-lanceolate, pinnatifid almost to the dark-coloured puberulous, naked or slightly ciliate rachis, elastico-chartaceous dull green nearly or quite naked, gradually or more or less abruptly reduced at the base; pinnæ horizontal, straight very numerous, linear-ligulate, acute or bluntish at the end, close, but broadening to and rather dilated at the base the sinus sharp or rounded adnate confluent and nearly equilateral 1-2½ in. l. 2½-4 li. w., the inferior reduced and decurrent through deltoid to broad shallow scallop-shaped lobes ¼-½ in. w. and less than a line deep which form a wing to at least the upper part of the stipites; veins once or twice forked, midrib slender, black, wavy toward the end; sori medial, round, terminal on the lowest anterior veinlet, 1-1½ li. apart in the rows :—Pl. Fil t. 83., Eat. Ferns N. Am. Pl. 42.

a. var. *caespitosum* :—Rootstock erect, or oblique, stipites tufted, 1-3 in. l. dark; fronds erect, few, 1¼-1½ ft. l. 2.2½ in. w., blunt or rounded, rachis and ribs puberulous; veins once-forked, short of the edge, the anterior fertile conspicuously shorter.

b. var. *Wagnerii* rootstock more decidedly woody, ¼ in thick, scales fine and very dark; fronds 1–1½ ft. l. 2–3 in. w.; stipites and rachises slender but stiff; pinnæ blunt or rounded, about 2 li. w. texture membranous and elastical, surfaces more decidedly glabrous; veins usually once forked, the outer branch much curved along the margin to the next one, where it is free or united to a short spur; sori medial on the shorter anterior branch.—*P. Wagnerii*, Mett.

Common at all elevations on open or shady wayside banks, rocks and trees up to 5,000 or 6,000 ft. alt., variable, including three or four distinct forms. It is best marked by its almost or quite naked surface, elastic texture, lower pinnæ suddenly or not reduced to auricles and sometimes into a scalloped wing along the stipites, and medial rather small yellow circular sori. The rootstock is repent with the fronds usually contiguous and erecto-drooping. *a* grows on stones under shade at Old England, at 4,000 ft. altitude. Its roostock is upright or oblique with the fronds tufted at the summit, shuttlecock-like in form; the rachis freely puberulous, a pellucid plait running from the sinuses to the rachis. This I have gathered also plentifully in Guiana. *b* is a slender but stiff plant, with longer wiry stipites and fronds more abrupt-

ly reduced at the base. The veins are usually once forked, but the outer branch curves forward by the margin so much that it occasionally unites with the next, and so forms an areola with an included sorus as in *Goniophlebium* but no internal veinlets.

39. *P. Paradiseæ*, Langsd & Fisch.—Rootstock strong, stout, short-creeping, clothed with slender brown linear small scales; stipites subtufted or contiguous, strong, erect, ½-1 ft. l., dark-brown, viscid-puberulous or slightly ciliate; fronds 1½–3½ ft. l. 4–10 in. w. elastico-chartaceous; slightly viscid-puberulous at length naked, dull grayish or brownish-green; pinnatifid almost to the strong, dark-brown or blackish viscid-puberulous, and rather rusty tomentose rachis; pinnæ very numerous, close, horizontal, ligulate, 2–5 in. l. 3–5 l. w., obtuse or rounded at the apex, dilated at the base, more usually on the upper side, adnate and confluent, the sinuses acute in the upper part of the frond, gradually widening to broadly V—shaped at the bottom with curved sides, the lower pinnæ more or less suddenly reduced through broad much dilated shallow segments; veins fine, oblique, twice forked, the lowest shorter anterior branch fertile at the end, all usually free, but casually the outer curved ones united; sori suboval, in a medial row between the raised dark midrib and margins, pale yellow; receptacle elongated.—Langsd. and Fisch, p. II. t. II.

Common on open banks and rocks from 3,000–6,000 ft. alt.; a much stronger and more robust plant than the preceding, but with the same texture, differing by the larger size, sub-oval sori, and glanduloso-puberulous or ciliate and rusty surfaces. The lower segments are dwarfed to mere uneven membranous margins on the upper part of the stipites.

40. *P. simile*, Linn.—Stipites ¾–1½ ft. l., rather slender, naked fronds 2–3½ ft. l. 4–6 in. w., pendent, elastico-chartaceous, naked, green fully pinnate at the truncate base, above this deeply pinnatifid to the strong, channelled, dark coloured, naked rachis; pinnæ spreading apart, the lower ones subdistant, broadly adnate by the expanded base; the upper ones connected by a narrow membrane and ½ in. w. open rounded sinus, linear-ligulate, 2–3 in. l. ½–⅔rd. in. w. even margined; veins free, 2–3 times forked; sori uniserial, terminal on the lower anterior veinlet.—Sloane Cat. p. 16. Hist. p. 77; tab. 32; plts. p. 51.

This has only only been collected by Sloane [on Mt. Diabolo] It presents a different aspect from any of the other members of the pectinatum group I have seen. From the other large species it is marked by its glabrous surface, uniformly broadly open pinnation, more often branched venation, and long pendent habit. Sloane describes it as five feet long having a a petiole 1½ ft. long. His specimen from which I have taken the foregoing description is 3 ft. long in the frond and 15 inches in the petiole.

41. *P dissimile*, Linn,—Rootstock fleshy, creeping, stoutish, densely clothed with bright-coloured much acuminated scales; stipites apart, 4-8 in. l., grayish, scaly at the very base; fronds oblong-lanceolate, 1½-2½ ft. l. 4-6 in. w., pinnate, the upper part deeply pinnatifid ending in a pointed subentire segment, membrano-chartaceous, pellucid, naked or the ribs puberulous above; pale or dark green; pinnæ spreading oblong-lanceolate, acuminate or acute, even-edged or crenulate-repand, all, or the lower ones at least, apart, but not distant, 2½-3½ in. l. ½-1

in. w., contiguous and narrowly confluent in the upper part, below this more or less adnate, chiefly in the upper base, the lower ones almost or quite free, and usually narrowed or rounded, often auricled or lobed on the inferior base, rachis rather slender, grayish or dark brown, puberulous or naked, with slight marginal lines; veins two or three times forked, the thickened apices not reaching the margins, the lowest anterior branch fertile at the end; sori yellow, oblong or oval the rows nearer the pale raised midrib than the margins; receptacles elongated.—*P. sororium*, Kth.

Frequent on rocks and trees, chiefly the former, in very moist woods among the lower hills, ascending to 2,000 ft. alt.; well distinguished by the alternately branched little oblique, veins, thin texture, adnate pinnæ, and bright aureate oval sori. The lower veins, near the base of the pinnæ usually unite, the branches of the same group often connecting. In some fronds the auricle or lobe at the base of the pinnæ is not shown, while in others all the unconnected ones have it $\frac{1}{4}$-$\frac{1}{2}$ in. deep.

42. *P. microchasmum*, Baker:—Rootstock shortly repent, rather slender, clothed with bright brown scales; stipites apart, erect $1\frac{1}{2}$-2 in. l. pale brown or stramineous, slender, glabrous, winged to the base, where there are a few scales like those of the rootstock; fronds oblong lanceolate, 5-8 in. l., $1\frac{1}{2}$-2 in. w., pinnatifid to the narrowly winged rachis, or fully pinnate below, with an entire terminal segment; light green, darker beneath, the surfaces naked except on the slender rachis beneath, which is clothed with deciduous dark brown minute and very acuminate scattered scales; pinnæ spreading obliquely, fully adnate and all but the lowest contiguous, $\frac{1}{2}$-1 in. l. 2 li. b. rounded at the end, and open with a more or less rounded oblique sinus between, the margins slightly notched at intervals; veins obscure, slender, simple or forked, terminating within the margin in pellucid clavate apices; sori circular, medial between the midrib and margin, terminal on the anterior branch of the veins, somewhat immersed.—Journ. Bot, 1887, p. 44.

Gathered at Tweedside by Mrs. Barrington Baker; differs only from *P. vulgare* of the north temperate zone by its more slender rootstock, and winged petioles. The only fronds I have seen are the size described. The lower pinnae are most open between with a deep well rounded sinus; in the upper ones the sinus is acute. The notches of the otherwise even and straight margin are shallow, but regular and distinct. On the upper side there is a cavity over the very pellucid and thickened apex of each vein. The sori, too, are slightly depressed. Including the wings, the petioles are 1 li. w.

43. *P. hastæfolium*, Swartz.—Rootstock small, upright, with strong wiry descending roots, the crown clothed with small brown scales; stipites densely cæspitose 1-2 in. l., grayish, clothed with scattered deciduous scales like those of the rootstock; fronds erecto-spreading, lanceolate, 5-10 in. l. 1-$2\frac{1}{2}$ in. w. the apex terminating in a lobato-entire point, gradually dwindling to nothing at the base, charactaceous or subcoriaceous, naked, dark-green above, paler beneath; pinnæ numerous, usually contiguous nearly or quite horizontal, $\frac{3}{4}$-$1\frac{1}{4}$ in l. $1\frac{1}{2}$-$2\frac{1}{2}$ l. b., linear-oblong or ligulate, the point blunt, the base quite free and dilated equally on each side into a pair of sharp auricles, lower segments minute triangular with sharp angles, margins even or faintly crenulate, rachis and ribs puberulous, the former grayish and channelled; veins forked, but sim-

ple in the outer part; sori dorsal near the forking, single or double, the rows rather nearer the midrib than margin.—Icon. Fil. t. 203. *Aspidum*, Gr.

Common on wet rocks and banks among the lower hills and ascending to 2,000 ft. alt., well marked by its small size and densely tufted habit with the hastate pinnæ. The rootstock is often 2-3 in. l. composed mainly of strong wiry compact descending roots which spread only when they reach the surface of the rock on which the plant is growing. The sori are as often double as single, one being borne near the base of each limb of the veins, so close together that they appear single. Grisebach must have detected trace of an involucre, as he removed the species to *Aspidium*.

44. *P. flavopunctatum* Kaulf.—Rootstock stout, decumbent, stipites strong, erect, dark brown, deciduously scaly below, channelled $1\frac{1}{2}$-2 ft. l.; fronds ample, 2-3 ft. l. 1-$1\frac{1}{2}$ or 2 ft. w., pinnate, the upper part pinnatifid, truncate and not reduced at the base, membrano-chartaceous and freely pellucid dotted, naked, dark green above, paler beneath, rachis strong, channelled, subangular, slightly fibrillose beneath; pinnæ numerous, spreading, 8-10 in. l. 1 in. or more or less w., serrato-acuminate. sessile, the upper ones adherent on the inferior base and decurrent, free on the upper, which is the deeper side, and developed into an enlarged lobe, lower ones quite free shortly stipitate and rather rounded, cut $\frac{1}{5}$–$\frac{1}{3}$rd to the costæ into shallow rounded oblique lobes, which are $1\frac{1}{2}$-2 li. w. and slightly crenate; veins pinnate, about 4-5 to a side, simple, the basal ones not uniting but falling suddenly short within the margin; sori medial, dark when dry.—*Aspidium rotundatum*, Willd. Pl. Fil. t. 38.

A very fine species, marked by the basal veins not uniting but curiously, falling short in the middle of the integument, the pellucid dots scattered over the surface, and the upper pinnæ adherent at the base on the lower side and decurrent on the rachis while free and enlarged on the upper side it resembles very much some forms of *Nephrodium serrulatum*, Mett. which species is sometimes confounded with it, but from which the free veins clearly distinguish it. It is ascribed to Jamaica by Hooker, on the authority of Wilson, n. 516, no locality mentioned.

45. *P. pubescens*, Radd.—Rootstock upright, the crown clothed with few pale-brown scales; stipites cæspitose, erect rather slender a few to several inches long, channelled, gray-pubescent; fronds chartaceous, light green, pellucid, pale pubescent, chiefly on the slender channelled rachis costæ and ribs, $1\frac{1}{2}$-$2\frac{1}{2}$ ft. l. 3-6 in. w. bipinnatifid; pinnæ numerous, contiguous or apart, alternate or opposite, spreading obliquely or horizontally, reduced gradually to the acuminate pinnatifid apex of the frond, and below, finally, to minute distant trilobed segments, central ones 2-$3\frac{1}{2}$ in. l. $\frac{1}{3}$rd–$\frac{3}{4}$ in. w. as wide or wider at the quite sessile base, acuminate with a serrate-entire point, within this pinnatifid nearly to the costæ; segments horizontal or oblique, $\frac{3}{4}$–$1\frac{1}{4}$ li. w. $\frac{1}{4}$–$\frac{1}{2}$ in. l. acute, close, the narrow sinus acute, the margins even or faintly crenate, often a little reflexed; veins simple, slightly oblique, 5-9 to a side all fertile; sori nearer the edge, often apparently amorphus when mature.—Radd. Piante Bras. t. 34.

Common in forest and on banks by waysides and streams, above

3,000 ft. altitude. Resembles in general aspect the following, with which it is often associated, but it is of more compact habit, softer densely pubescent substance, pale green colour, and more copious sori. The habit is very erect, but the parts slender and rather fragile. In plants growing in the open, the sori gradually conceal the entire under-surface, passing from yellowish-green to dark blackish-brown at maturity.

46. *P. gracilentum*, Jenm. n. sp.—Rootstock upright, fribrous, an inch or so thick, stipites slender, cæspitose, erect, gray-green, channelled, ½-1 ft. l., naked or puberulous, a few dark scales at the base; fronds erect-spreading shuttle-cock form, bipinnatifid, 1½-3 ft. l. 5-8 in. w., weakly, dark green, paler beneath, naked except on the slender channelled, rachis costæ and ribs which are finely puberulous-pubescent, oblong-lanceolate, tapering both up and down, gradually to the apex into the lobed, serrulato-entire point; pinnæ distant, the inferior dwindling to remote segments ligulate, spreading nearly horizontally, 3-4½ in. l. 3-8 l. w., opposite or sub-opposite, sessile, the acuminate point evenly entire, pinnatifid nearly to the slender slightly flexuose costæ; segment 3-5 li. l. 1-1½ li. w. blunt or subacute, open, slightly dilated at the fully adnate base, the basal pair slightly enlarged, the margins even or faintly crenulate and slightly reflexed; veins simple, oblique, 6-8 to a side, that on the inferior base sometimes forked, raised on the upper surface; sori nearly medial occupying usually all the veins, superficial or slightly sunk.

Common from 3,500-5,000 ft. alt. in grass by the sides of open shallow streams and in similar wet exposed places; of a dark green colour, and pale brown, fragile, very slender vascular parts, the upper surface in some cases appearing as if crinkled from the raised venation and slightly impressed fructification. From the very apex of the fronds the pinnæ steadily widen apart downwards to 1–3 in. in the small lobate segments to which the inferior are reduced. There is a variety occupying the same situations, possessing the some general aspect, but with narrower quite horizontal pinnæ, and close straight horizontal segments and less obvious venation. I have both also from Cuba. For many years this was referred to *Neph. conterminum*, Desv.—a species of particularly well marked identity but regarding which there is great confusion.

47. *P. ctenoides*, Feé.—Stipites cæspitose from a strong upright rootstock, 1–1½ ft. l., strong, densely rusty pubescent; fronds erect, 2-2½ ft. l. 8-12 in. w., chartaceous, stiff, dark green and glossy above, paler beneath, slightly ciliate or naked, glandulose puberulous beneath, the costæ hispid-pubescent as is also very densely the rachis, which is grayish or rusty and channelled; pinnæ spreading contiguous, sessile, with a projecting gland at the base beneath, 4-6 in. l. ⅘-⅞th in. w., very acuminate, passing through serratures to the sharp entire point, deeply pinnatifid to within a line of the costæ, the lower ones suddenly reduced to very minute segments which, at intervals, descend the stipites; segments close, nearly straight, oblong, obtuse-acute, 4-5 l. l. 1½ l. b. hardly dilated at the confluent base, the basal pair, except in the upper part of the fronds, reduced; margins slightly reflexed; veins simple, rather oblique, pellucid while fresh, 12-15 to a side; sori medial, soon dispersed. *Phegopteris*, Feé. Fil. Ant. t. 14. fig. 2.

Common between 4,000 and 6,000 ft. altitude in open or shady moist situations; abundant in parts of the Government Cinchona Plantations; near to, if not identical, with *P. rude*, Kze. Colour very dark green, texture stiffish and hard, surface densely rusty-gray hispid, on petiole rachis and ribs, with a general harsh feel, and slightly ciliate or not on the veins and margins. A much stronger plant than *P. gracilentum* but of similar general resemblance.

48. *P. Thomsonii*, Jenm.—Rootstock stout, upright, often a few inches high; stipites cæspitose, erect, 1-2 ft. l. brown, clothed downwards with membranaceous brown scales, and mucous when young; fronds membrano-chartaceous, pellucid, nearly naked, slightly glandulose beneath puberulous or ciliate on the costæ and ribs, pale but vivid green, 2-4 ft. l. $\frac{3}{4}$-$1\frac{1}{4}$ ft. w. oblong or ovate lanceolate, acuminate, somewhat shortly reduced at the base, rachis channelled, grayish puberulous or pubescent, and pale coloured; pinnæ spreading, numerous, contiguous above, sub-distant below, sessile with a subulate gland at the base, 6-8 in. l. 1-$1\frac{1}{4}$ in. w., oblong-lanceolate, acuminate, with a serrate entire point, the 2-3 lower ones reduced half or more, and often deflexed, pinnatifid to half a line of the costæ; segments numerous, close straight, oblong and round-ended, confluent but not dilated at the equal-sided base, 6-7 li. l. $1\frac{1}{2}$-2 li. w., flat with entire margins; veins simple, slighty oblique, pellucid while fresh, 12-15 to a side, sori medial, or nearest the midrib, brown, constantly distinct, at length dispersed.—Journ. Bot. 1886, p. 272.

Infrequent in forest or shady places at 6,000 feet altitude; gathered in the hollow at Newhaven Gap at the top of the Cinchona Plantation. Resembling most the next species, but much smaller, and flaccid with a general pale colour, distinct never confluent sori, relatively few veins, and absence of the murications of stem and rachis, and pubescent and nearly stramineous rachis. It is named after Mr. Robert Thomson, the founder of the Government Cinchona Plantation.

49. *P. decussatum*, Linn.—Rootstock very stout, decumbent; stipites cæspitose, stout, erect, not channelled, dark or purple-brown, 2–4 ft. l., membranous scaly throughout, and coated with glutinous mucous, biserially muricate down the sides; fronds erect, 4–6 ft. l., $1\frac{1}{2}$-$2\frac{1}{2}$ ft. w., subcoriaceous, stiff when dry, naked except on the ribs; pinnæ numerous, close, spreading horizontally, sessile, with a lanceolate, brown, $\frac{1}{4}$ in l., conspicuous gland at the base 10–15 in. l., about $1\frac{1}{2}$ in w., acuminate, with a serrate-entire point, pinnatifid nearly to the costa; segments very numerous, close, even edged, horizontal, linear-oblong, rounded at the end, adnate and confluent at the equal-sided base, $\frac{3}{4}$ in. l., $1\frac{1}{2}$ li. w.. rachis very strong rather rounded, not channelled, naked, purple, muricate along the sides like the stipes; costæ puberulous beneath, pubescent above; veins simple, slightly oblique, pellucid, very close $2\frac{1}{2}$–3 dozen to a side; sori medial or nearer the midrib, copious, purplish, ultimately confluent.—Pl. Fil. t. 24. *Glaphyropteris*. Presl.

Common in moist forests, especially near streams, at 2,500–4,000 ft. alt. A fine plant of striking aspect, and some peculiar features. The strong purple rachis and petiole, muricate along the sides, long horizontal pectinate pinnæ, and claret coloured confluent sori distinctly mark it.

50. *P. caudatum*, Kaulf.—Rootstock stout, erect, scaly; stipites cæspi-

tose, strong, erect, channelled, paleaceous throughout but densely so below, 2–3 ft. l.; fronds 2–3½ ft. l. 1–1½ ft. w. bipinnatifid, sub-chartaceous, pellucid, with scattered pale dots, naked, only a few small scales on the costæ and ribs, pale-green on both sides; rachis light coloured, deciduously paleaceous and fibrillose, but less so than the stipites; pinnæ spreading, the lower ones horizontally and not, or hardly, reduced, opposite, or contiguously alternate, close above and sessile apart, below and stipitate 6–10 in. l., 1–2 in w., the lowest 1–2 pair rather deeper on the inferior side, the point finely serrate-acuminate, within this pinnatifid to the narrowly winged costæ, segments spreading but rather oblique, ½–1 in. l., or over, 2–3 or 4 l. w., linear-oblong, shortly acute or bluntish, rather dilated and confluent at the base, with a close or open sinus between; margins faintly or deeply toothed throughout, sometimes lobate in the bottom pinnæ, the teeth bluntish; lowest segment on the upper-side usually largest and the opposite on the inferior smaller or in the lowest or lower pinnæ often absent; veins simple or forked, pellucid, 6–10 or 12 to a side; sori confined to the outer ½ or ⅓rd of the pinnulæ, nearer the midrid than margin.

Common in damp forests near streams, principally in the mid region of the great mountain range. In the largest fronds the inferior pinnæ are fully pinnate toward the base on the underside. Where the veins are forked, the longest branch terminates in the tooth, with a thickened summit, and the shorter near the sinus. The species is marked by its general pale colour, diffused, paleaceous vestiture, scattered yellow pellucid dots, toothed segments, and sori on the outer part, though this last character is not absolutely constant. As mentioned under that species, this and the common form of *Asplenium conchatum* have exactly the same cutting, barren fronds of each being hardly distinguishable one from the other.

51. *P. punctatum*, Thunb.—Rootstock wide-creeping, rather slender, scurfy with fine rusty scales that ascend the base of the stipites; stipites erect, distant, naked, channelled, castaneous and glossy, 3–5 ft. l.; fronds subdeltoid in outline, 4–6 ft. l. 3–4 ft. w, chartaceous, naked, or slightly puberulous viscid beneath and pale dark-green above and glossy, triquadripinnatifid; pinnæ petioled, in distant spreading pairs, decreasing from the base of the fronds upwards, the lower ones 1½–3 ft. l. 9–12 in. w, ovate-acuminate, the upper oblong-acuminate; pinnulæ also distant, similar in shape to the pinnæ and petiolate, those on the inferior side usually a little larger, the costulæ flattish or narrowly margined; tertiary segments distant, oblong, usually quite sessile, the outer rounded and merely crenate, the inner bluntish or acuminate, lobed or deeply pinnatifid, larger ones 1–2 in l. ¼–½ in. w.; ultimate lobes 1–1½ li. b, rounded and crenate; rachis and costæ bright and castaneous, or the latter varying to stramineous; veins pinnate the branches simple or forked in the final lobes; sori copious, terminal, round or oval, rather large, submarginal, one within each partially reflexed crenature.

Frequent but not common at 4,000–6,000 ft. altitude on the skirts of forests, open banks, and waysides. This is quite identical in habit and cutting with *Hypolepis repens*, differing only in its naked glossy surface, the absence of the pale involucral marginal scales, and the sori at first more or less clearly within the margin, dorsal

or terminal on the veins. The rootstock branches and spreads widely under the surface of the ground, and the bright colouring of all parts of the surface and sori gives the ample fronds a very attractive aspect.

52. *P. rugulosum*, Labill.—Rootstock slender, widely repent, stipites apart, erect, dark brown, channelled, freely paleaceous and slightly asperous, 1–3 ft. l.; fronds 1½–3½ ft. l. 1½–3 ft. w erect, tripinnate, deltoid-oblong, thinly chartaceous, viscid, fibrous, pellucid, rachis, costæ and ribs, densely clothed with appressed imbricating glossy bright brown scales, and faintly asperous; pinnæ spreading nearly horizontally, distant in opposite or sub-opposite pairs, 1–1½ ft. l. 3–6 in w., the upper sessile, the lower petiolate; pinnulæ oblong, acute, fully pinnate only at the sessile base, 2–3½ in. l. 1 in w; segments ¼–¾ in. l. 2–3 li. w., oblong, adnate, decurrent, upper base decurved, lobed, dentate or crenate, the end rounded and even; veins once or twice forked in the teeth or lobules; sori copious, dorsal on the anterior veinlet, near above the furcation, bright fulvous

Infrequent in the higher mountain regions on banks skirting byeways and forests and other half open places; easily mistaken for *Hypolepis repens* and *H. Purdieana* with which it conforms in habit and cutting, differing by the dorsal, medial sori too distant to be covered by marginal crenatures. This and *punctatum* and the local species of *Hypolepis* in their final cutting resemble the more compound species of *Lastrea*, such as *villosum*, *amplum*, *Grisebachii* and *nemorosum*.

53. *P. nigrescentium*, Jenm.—Rootstock strong, stout decumbent or oblique, shortly repent, dark, scurfy, clothed with a few minute dark-brown scales; stipites more or less tufted, erect, 3–7 in. l., slightly channelled, puberulous, a few minute dark brown scales at the base; fronds erect, pinnate, subcoriaceous, dark green, glossy, pellucid, glabrous, the rachis brown puberulous, 3–5 in l. 2–4 br. composed of 3–7 spreading sessile oblong lanceolate acuminate pinnæ and a similar terminal one, which are 1½–3 in. l. ⅓rd–½ in. w., the upper ones truncate, the lower rounded or sub-cuneate and not reduced, repand, the margins slightly lobed or serrulate-crenate; veins 4–5 to a side, the opposite ones connecting at an angle with an intermediary that runs to the sinus and is very pellucid at the top; sori copious, occupying all but the exterior veins, and covering most of the surface.—Gard. Chron. Jan. 26, 1895.

Among the lower hills; St. Mary parish. Intermediate between *crenatum* and *obliteratum* in its general characters. Its characteristic features are the relatively strong rootstock, small densely grouped fronds, repand and crinkled very slightly cut pinnæ and copious sori.

As a rule the terminal segment is shortened, which gives the fronds an oblong or quadrariform aspect that is very characteristic. As in all these species, in the very early stage of the sori a rudimentary trace, of, hardly more substance than a film, of an involucre can be detected with a lens.

54. *P. obliteratum*, Swartz.—Rootstock subterranean, strong short creeping; stipites sub-tufted, 1½–3 ft. l. erect, grayish or dark coloured with a few deciduous purplish scales at the base, subangular, hardly channelled; fronds erect, ovate oblong, 1¼–1¾ ft. l. ¾–1¼ ft. w., subcoriaceous, naked, or glabrescent beneath, dark green, pinnate, not

reduced at the base; pinnæ apart or sub-distant, spreading or erecto-spreading, 6–9 to a side with a similar free terminal one, 5–8 in. l. ¾–1 in., or rather over, w., those of the barren fronds being the wider, the base sub-entire cuneate and shortly stipitate, the upper ones more rounded and often slightly adnate, the apex acuminate, rather long-pointed, and entire, the margins within this very shallowly cut into broad appressed or oblique rounded lobes, which are 2–3 li. b. and less than a li. d.; veins pinnate, branches simple, 6–9 to a side, most connected with the casually interrupted veins that run to the sinus; sori purple, copious, dorsal; biserial extending from the costæ to the margins, and to the acuminate points of the pinnæ.—Hook. Icon. Plt. Third series, Pl. 1669.

Common in woods and stony half open ground among the lower hills, up to 2,000 or 3,000 ft. altitude. In the early stage of growth trace of a rudimentary involucre is observable, which however soon disappears. Intermediate between *crenatum* and *tetragonum*, and distinguished by its stiff texture, very slightly incised pinnæ, with generally appressed flat lobes, naked surfaces, dark colour and purple sori. *Goniopteris hastata*, Fée. (Nephrodium, Jenm.) and *G.* Rivoirei, Fée Fil. Ant. t. 18 are near this, if not the same.

55. *P. crenatum*, Swartz.—Stipites subtufted, erect from a creeping under-ground rootstock, 1-2 ft. l., strong, light coloured, glabrescent, subangular, channelled; fronds erect 1-1½ ft. l. and nearly as w., at first flaccid, at length thinly chartaceous, pubescent, mostly on the ribs and veins, dark dull green, composed of 3-6 pairs of spreading or erecto-spreading lateral pinnæ and a free similar large terminal one, pinnæ 6-9 in. l. 1½-2 in. b., shortly acuminate, the lower ones subcuneate, at the base, the upper rounded, lowest pair as large or larger, the uppermost one often shortly adnate to the pubescent or naked subangular rachis; margins subentire or cut into very shallow rounded or rather appressed lobes which are a ¼ in. w. and hardly more than ½ li. d.; veins pinnate, the branches simple, nearly all connected with the vein running to the rims, the latter casually interrupted; sori copious, round or oblong, dorsal, the lines reaching from the midrib to the margin.—Pl. Fil. t. 111.

Common in woods and shady places among the lower hills; very well marked by the few large slightly cut pinnæ, thin texture, and pubescence. The pinnæ are sometimes bulbiferous near the base on the upperside, and the terminal one is not more lobed than the lateral. I have a Jamaica specimen every sorus covered completely by a much ciliated involucre. Its nearest alliance is with the next species.

56. *P. tetragonum*, Linn.—Stipites erect, few, subtufted from a strong short-creeping epigeous rootstock, 1-2 ft. l., subangular, glabrescent or puberulous, stramineous; fronds firm, pellucid, bright clear green, naked, or slightly ciliate on ribs and margins, 1-1½ ft. l. 7-10 in. w., pinnate, not reduced at the base; pinnæ apart or distant, 8-10 to a side, spreading, often horizontally, with a rather larger pinnatifid free terminal one, only the lower 1-2 pair shortly narrowed at the base, 4-6 in. l. ½-1 in. w., the barren wider, acuminate with an entire point, within this uniformly lobed to ½ the depth to the costæ; lobes close, oblique, rounded, 1½-2 li. w. entire; veins pinnate, about eight to a side, simple, 2-4 lower pair united with the branch to the sinus, which is often interrupted;

sori copious, dorsal, biserial near the midveins, extending from the base to the apex of the lobes.—Pl. Fil. t. 16.

var. a. *megalodus.*—Fronds much larger, pinnæ 6-9 in. b. 1¼-1½ in. w.; lobes ¼ in. w. P. *megalodus,* Schk. Pl. Fil. t. 21.

var. b.—Pinnæ relatively fewer and longer, 6 in. l. ¾ in. w. lobed ⅓rd deep or more; colour dark gray green, the under surface microscopically blistered, and costæ and veins densely gray stellate-puberulous; sori with a gray rudimentary involucre.—*Goniopteris quadrangularis,* Fée, Fil. Ant. t. 16. fig. 3.

var. c.—Fronds much smaller; pinnæ 2 in. l. ¼-⅓ or ½ in. w., often passing gradually into the pinnatifid apex.

var. d.—Fronds small, with a terminal rather larger pinnæ as in the type, lateral ones about 1½ in. l. ½ in. w. or less; colour dark; only the basal pair of veins united.

var. e—Stipites tufted, slender; fronds relatively small; pinnæ relatively broad; 1½-3 in. l. ½-¾ in. b. costæ and ribs ciliate beneath, texture thin and very pellucid, colour light or yellowish green; sori often not reaching the base of the inferior pinnæ.

Very common below 2,000 or 3,000 ft. altitude, growing in grassy and open or half open and little shaded places. The sterile fronds spread on shorter stipites, with fewer broader pinnæ; the much taller fertile erect. *A*, regarded by Mittenius and Grisebach as distinct, only differs by its uniformly much larger size, *Nephrodium brachyodon,* Hk. is often mistaken for this. *c, d* and *e* are reduced varieties. Fée describes five varieties, which apparently only vary within the limits of what, taking the variation of aspect due to wide range and other conditions, may be regarded as the type. Rudimentary involucres are detectable in young specimens, more often in some varieties than in others.

57. *P. incanum,* Swartz.—Rootstock wide-creeping, as thick as cord, densely coated with subulate dark-centred pale ciliate-edged scales; stipites scattered, 3-4 in. l., coated with appressed scales; fronds 3-8 in. l. 1½-2½ in. w. elastic-coriaceous, opaque, oblong-lanceolate, as broad or broadest at the base; cut nearly or quite to the rachis into horizontal linear-oblong rounded pinnæ, which are ¾-1¼ in. l. 2-3 li. b. dilated at the base, with a rounded sinus and 1-3 times their own width between, densely coated and gray beneath with appressed imbricating peltate dark-centred fimbricate scales, those of the rachis different, upperside sparsely scaly, or at length naked and dark green; veins concealed; sori uniserial nearer the margin, protruding through the felt-like vestiture. Sl. Herb. P. 60. Acrostichum polypodioides, Linn. Eat. Ferns N. Am. Pl. 26.—*Polypodium minus,* Pl. Fil. t. 77.

Common on rocks and trees in open situations and forest of light shade, ascending from the lowlands to 5,000 ft. altitude. In dry weather the very elastical fronds involutely curl, and appear as if dead, expanding again with rain. This is the smallest species of the group, with scales less acuminate, and clearly distinguished by its very wide-creeping rootstock, which branches and intercrosses freely forming a network on whatever surface it is growing.

58. *P. thyssanolepis,* R. Br. —Rootstock creeping, clothed with narrow acuminate pale-edged fimbriate scales; stipites erect, usually contiguous, 6-9 in. l., and with the rachis freely scaly; fronds 5-8 in. l. 2½-3½ in. w., much the broadest in the lower part; pinnæ spreading,

8-12 to a side, with a similar terminal one, linear-oblong, 1¼-2 in. l. 3-4 li. b., bluntish, mostly contracted and then dilated at the barely confluent bases, subdistant, subcoriaceous; upper surface dark green, and slightly scaly, under densely felted and grayish with larger pale acuminate fimbriate scales; veins obscure, costæ row of areolæ not large, with smaller internal ones; sori uniserial, near the midrib, immersed in the scaly vestiture.—*Goniophlebium rhagadiolepis*, Fée. Mem. Fil. t. 19, fig. 3.

Frequent on rocky banks at 4,000-5,000 ft. altitude; common near the Government Cinchona Plantations; distinguished by its short broad fronds, few pinnæ, small copious areolæ, and stiffer habit in growth. There is often a line of crustaceous dots around the margins of the pinnæ on the upperside. This and the preceding are quite truncate at the base, the two following are not.

59. *P. squamatum*, Linn.—Rootstock creeping, densely clothed with fimbriate pale-edged dark very acuminate scales; stipites contiguous, 4-8 in. l., scaly or at length naked; fronds lanceolate—oblong, 10-15 in. l. 2½-3½ in. b. usually a little reduced at the base, elastical-coriaceous, the under surface densely matted with acuminate dark-centred, pale-edged fimbriate scales, the upper slightly so and dark green; pinnæ very numerous, spreading nearly horizontally, with their own width or more between them, linear ligulate, 1¼-2 in. l. 2-2½ li. b., bluntish or acute, the base equally dilated, the lower ones, disconnected the upper confluent by a very narrow margin; veins obscure, forming a costal line of areolæ; sori immersed in the felt-like vestiture, uniserial, medial or nearer the costæ. Pl. Fil. t. 79.

Frequent on rocks, banks and trees from the lowlands, where it is general through the country, up to 5,000 ft. alt. where it is more abundant. The scales of the rootstock have a light rather reddish tinge when old The rachis is strong, and the scales that clothe it much attenuated, and the fronds have a distinct terminal pinna. The lower pinnæ are ¼-½ in. apart. These are often barren, but on the others the sori are very abundant reaching from the base to the apex.

60. *P. lepidopteris*, Kze.—Rootstock creeping as thick as a quill, densely coated with narrow-fringed scales having a ferruginous tinge; stipites approximate, 2–6 in. l., scaly; fronds ¾-1½ ft. l 3–4 in. b. gradually tapering to the apex, the base reduced more or less abruptly to mere deltoid small segments, subcoriaceous and rather elastical, freely coated, but most densely beneath, with peltate-caudate pale-fringed, appressed scales; pinnæ very numerous, horizontal, linear-ligulate, acute, 2 in. l. 2½ li. b., dilated equally at the base and narrowly confluent by an open rounded sinus, or the lower ones unconnected, with about twice their own width between them, those above the middle somewhat narrowed above the expanded base; sori unserial near the midrib, immersed in the felt-like coating; veins forming a single line of costal areolæ on eachside.

Infrequent on rocks banks and in strong places at 4,000–5000 ft altitude. Very near *squamatum* which it closely resembles in the shape but differing in the more flaccid texture while growing, more copious and paler silky vestiture, and the form of the dwarfed basal segments. My specimens taper gradually to the apex which terminates in a

small lobe, while in all the other species the passage is more or less abrupt into the terminal segment, which in these is much larger. Up to maturity the fronds have a most beautiful silky lanate appearance ; when older, tawny.

61. *P. loriceum*, Linn.—Rootstock as thick as a quill, firm, wide-creeping or trailing, variegated with appressed, scarious and pale-margined brown scales, stipites distant brownish, naked, 6-12 in. l. ; fronds lanceolate, ovate lanceolate or ovate, 1-1½ ft. l. 5-10 in. w. chartaceous, quite naked, brownish green, not or very little reduced at the base, with a narrow acuminate subentire apex, pinnatifid to the narrowly margined rachis ; pinnæ numerous, horizontal or subfalcate, the basal ones deflexed or not, ligulate, acute, acuminate, or often attenuated, entire crenate or serrulate-repand, 3-6 in l. ¼-½ in w. contiguous, dilated and surcurrent at the fully adnate and barely confluent base, the sinuses upcurved, the lower ones most open ; veins evident, very pellucid, areolæ in 1-2 rows, free exterior veinlets thickened at the summit and entering or not to the pellucid edged margin ; sori yellowish, 1-2 serial.—Pl. Fil. t. 78.

Most abundant trailing over the forest floor and on banks and the butts of trees in moist regions from 2000-6000 ft altitude ; variable in the shape of the frond and pinnæ and in texture venation and sori, but well distinguished by the very long slender cylindric rootstook, the peculiar scales, the pinnæ surcurrent at the base, and the veiny looking surface. Usually it has only a single row of areolæ and sori against the midrib, and the margins of the pinnæ are even. The rachis is straw coloured in the upper part or throughout. Occasionally a frond is found with the lowest or other pinnæ forked and a form in which the pinnæ are broadened above the base, and deeply pinnatifid with numerous linear segments, bearing exactly the same relation to the type that the variety *cambricum* does to *P. vulgare*, L.

62. *P. chnoodes*, Spreng.—Rootstock ½ in. thick, fleshy, creeping, densely clothed with blackish hairlike attenuated and reticulated scales ; stipites apart, slender, arching, ½-1 ft. l., stramineous and grayish-puberulous ; fronds pendent, flaccid, ultimately chartaceous, pubescent, grayish-green, 1½-3 ft. l. 5-10 in. w, pinnatifid in the upper part, pinnate in the lower ; pinnæ 3-6 in l. ½-¾ in w., ligulate and generally acuminate, horizontal or subfalcate, or the lower ones deflexed and recurved with the inferior side at the base free and auricled, the superior partly or fully adnate on both sides, slightly dilated or shortly surcurrent and narrowly confluent, all more or less separated, most so towards the base, margins entire ; the rachis slender, puberulous and straw coloured ; veins fine, areolæ 2-4 serial, reaching nearly to the margin ; sori 2-4-serial, small.

Common on trees and banks in open or shady places from 1000-4500 ft. altitude. Very distinct ; characterized by the fleshy rootstock and fine reticulated scales, pendent habit of the fronds, gray vestiture, soft texture, copious areolæ and small sori. The pinnæ are mostly opposite, and the 1-2 bottom pair a little reduced and narrowed at the base on the underside.

63. *P. attenuatum*, H.B.K.—Rootstock creeping, the advancing part fleshy, ¼-½ in. thick, densely clothed with imbricating ovate-acuminate bright brown scales ; stipites erect, ½-1 ft. l. naked, dark or light

brown. rather glossy; fronds subcoriaceous, naked brown-green, glossy, erect, ovate-oblong or ovate, $\frac{3}{4}$-$1\frac{1}{2}$ ft. l. $\frac{1}{2}$-$\frac{3}{4}$ ft. w., with a stiff brown glossy rachis and a terminal pinnæ, usually not free, and about a dozen oblique lateral ones, which are 4-6 in. l. and $\frac{1}{3}$rd-$\frac{2}{3}$ths of an in. w., straight or curved, narrowed to the base, the lower ones most so, and adnate, with an open space between them, acute or acuminate, entire; veins evident, the main ones oblique, areolæ 2-3-serial; sori 1-2 serial, brown.

Very common in the mid-region of the great mountain range, growing in coffee plantations and on wayside banks. Generally the pinnæ are narrowed to the base, a little at the top of the frond, gradually increasing to much at the bottom, and all are adnate to the rachis. There is however a form in which, except the two or three upper ones, they are all free, and not narrowed, but rounded, the lower ones cuneate, the lowest of all stipitate, and in which the venation is not raised beneath, and the second row of sori is close to the margin.

64. *P. neriifolium*, Schk.—Rootstock creeping, often freely, $\frac{1}{2}$-$\frac{3}{4}$ in. thick, fleshy in the growing part, densely clothed with bright broadish acuminate scales having a pale scariose margin; stipites 1-$1\frac{1}{2}$ ft. l., strong, brown or castaneous, naked and rather glossy; fronds subcoriaceous, quite naked, dull dark green, pendent, $2\frac{1}{2}$-$3\frac{1}{2}$ ft. l. 1-$1\frac{1}{2}$ ft. w., not, or hardly, reduced at the base, pinnate; pinnæ subdistant, spreading, rather upcurved in the outer part, 8-10 in. l. $1\frac{1}{4}$ in. w., 12-20 to a side with a similar terminal one, acuminate, the upper ones more or less adnate to the glossy dark brown rachis, those below gradually less so and becoming cuneate, the basal ones stipitate and almost free, the margins entire or crenate-repand; venation conspicuous, areoæ 4-serial; sori rather large, slightly impressed, in 1 or more rows, the inner are always complete.—*Goniophlebium menisciifolium*, Fée.

Infrequent among the lower hills on shady banks. Distinguished mainly from *attenuatum* by the much larger size, pendent habit and darker colour. The stout rootstock often extends a foot or two long and interlaces, lifting from the ground in a large mass.

65. *P. surrucuchense*, Hook.—Rootstock short-creeping, fleshy in the younger part, densely coated with ovate, or lanceolate acuminate, reticulated castaneous scales; stipites erect or suberect, naked, browish, 6-12 in. l.; fronds 9-18 in. l. 6-12 in. w. subcoriaceous, pellucid, deep green, often with a metallic tinge beneath, quite naked, not reduced, truncate at the base, fully pinnate throughout, the rachis rather slender, stiff, glossy, brownish; pinnæ oblique or the lower ones horizontal, $\frac{1}{2}$-1 in. apart, nearly or quite opposite, ligulate-acuminate and attenuated, 4-7 in l. 3-5 li. w., 6-12 or more to a side, and a similar long terminal one which has usually 1-2 pairs of short rounded basal lobes, the lower ones unequally subcordate or obliquely rounded at the base, the lowest shortly stipitate, the upper slightly adnate, entire or repand in the outer attenuated part; veins pellucid, forming a single row on each side of costal areolæ; sori bright aureate, uniserial, nearly a line in diameter.—Hook. Icon. t. 69.

Infrequent on trees and logs in forests and coffee plantations from 3,000-6000 ft. alt. By its vivid deep green clear colour and ruddy sori this a most attractive species. In the terminal segment, which is rather broader than the lateral, an attempt is occasionally shown to

form a second row of sori. It is very near *P. remotum*, Baker, of New Granada and British Guiana, which has thinner texture, ciliate surface, repand margins, and peculiarly long scales to the rootstock.

66. *P. aureum*, Linn.—Rootstock an in. or less thick, branched and free creeping, very densely clothed with long soft reddish narrow attenuated scales; stipites scattered, strong, glossy, with a tuft of scales at the base like those of the rootstock, 1-2 ft. l.; fronds pendant, or arched, 2-3½ ft. l. 1¼-1¾ ft. w., cut down to within a ¼ in. of the repandly winged strong glossy rachis into numerous spreading subdrooping pinnæ with open rounded sinuses their own width, less or more, between and with a similar more or less developed terminal pinnæ; chartaceous or subcoriaceous, naked, dark or light green pinnæ ligulate, 6-10 in. l., ½-1½ in. w., gradually tapering outwards to the narrow acuminate point, or often contracted just above the dilated base, lowest ones not reduced, repand cartilaginous-edged, entire, or with faint, broad, appressed dentations; veins very slightly raised, without stronger primary ones, areolæ copious; sori ruddy, in a single or double usually medial series, sunk, the upper surface more or less distinctly papilose.—Pl. Fil. t's. 76 and 80. Eat. Ferns N. Am. Pl. 16.

a. var. *reductum.*—Fronds much smaller, but pendant, and conform in colour; pinnæ ¼-½ in. w., with an open rounded sinus between; venation rather more prominent; sori copious, in a single medial series reaching down to the stramineous rachis; margins not (or very little) repand.

b. var. *areolatum*, H. B. K.—Fronds smaller, stiff and often erect, surfaces glaucous; stipites and rachises usually dark coloured and polished; pinnæ closer, not contracted near the base, ½-¾ in. w.; venation stronger and more prominent; sori larger, 1 serial, on simple or united veinlets; margins less repand.

c. var. *pulvinatum*, Link.—Fronds large. 2 or more ft. l. 1¼ ft. or more w.; pinnæ closer, contiguous in the upper part, broad, acute-pointed, 1¼ in, w.; surfaces rather glaucous; stipites and rachises dark-brown, polished; venation prominent, with stronger primary veins running to the margins, areolæ often containing free sterile veinlets; sori in two or three series on each side the midrib.

Common at low elevations and among the lower hills and mountains, growing on banks and the stems of palms, and branches of cotton and other very high trees, where it luxuriates among wild pines. It presents considerable variety in size, width of pinnæ, sori, habit &c. *a* is a pendant variety, large, but much smaller than the type, with pinnæ only ¼-½ inch wide. *b* is very abundant in the midregion of the great mountain range between 2,000-4,000ft. alt., growing on trees and decaying logs on waysides and in coffee fields, and is much stiffer than any of the rest, being generally erect or sub-erect in growth. It is peculiarly glaucous. There are reduced states of this, hardly larger than one's hand, with few short close pinnæ, more or less fertile. *c* approaches the type in size but the pinnæ are close and the sori constantly multiserial. It is found on rocky banks at 2,000-4,000 ft. alt.

67. *P. decumanum*, Willd.—Rootstock creeping, an inch or more thick, fleshy, densely clothed with long soft linear subulate reddish or fulvous undulate ciliate-edged scales; stipites 1½-2½ ft. l., strong naked, glossy;

fronds chartaceous, naked, green on both sides, 2–4 ft. l. 1–2 ft. w. with a long terminal acuminate pinna and several erecto-spreading lateral ones, that are about a foot long and 2–2½ in. w. the margin even or repand-dentate, decurrent and connected at the base by a narrow wing to the rachis; sinuses oblique, rounded and open by the narrowing of the base of the pinnæ, rachis and costæ slender, dark polished; main veins distinct in parallel lines to the margin, areolæ regular sori impressed, small, multiserial, occupying all the space be tween the midrib and the margin. Vide Baker Kew Ferns, 1874-91, p. 88.

This very fine and very distinct plant is distinguished not only by its larger size and green colour from any of the forms of *aureum*, but by its distinct and regular primary venation as compared to theirs, and the much more plentiful sori, of which there are 4–6 series between the costa and margin and which are often cretaceous dotted on the upper side of the fronds.

68. *P. petrafolium*, Jenm.—Rootstock strong, short-creeping, scaly; stipites few, contiguous, suberect, stiff but slender and wiry, 3–8 in. l. dark-brown, naked; fronds coriaceous rigid, naked or nearly so, grayish-brown ½-1 ft. l. 4–6 in. w. deeply pinnatifid, rachis and midribs concealed under the pagina, the wings of the former together about as broad as the pinnæ; pinnæ 6–10 or 12 to a side, erecto-spreading, often unequal, 2–3 li. w. 3–6 in. l., uniform in width or tapering to a bluntish point, dilated and both sur-and decurrent at the base, with broad oblique rounded sinuses¼- ½ in. w., terminal pinna similar, longer or shorter not wider, the margins even or slightly sinuate; veins immersed, obscure, forming narrow angular areolæ; sori large uniserial but interrupted and irregular, occupying the whole width from the midrib to the margins.—*Drynaria elastica*, Fée, Fil. Ant. t. 20. fig. 2.

Rare at 2,000–3,000 ft. altitude, growing on decaying logs in coffee plantations, and on trees; gathered at Murray's Flat, Mt. Moses, St. Andrew, where a single plant was found. It is well marked by its narrow rigid pinnæ and relatively large sori. It differs from *P. angustum*, Mett, with which it is united at Kew, by the different form of the frond, and entire absence of the peltate scales which clothe the surface of that species. As in *P. curvatum*, the entire vascular ramification of the frond is concealed in the pagina. In my specimens the pinnæ are 6–8 to a side, and the lowest pair shortly decurrent or not on the stipites Fée's name is inadmissable, it having been given to several species in the genus.

69. *P. crassifolium*, Linn.—Rootstock woody, short-creeping, clothed with largish dark brown ovate-acuminate, reticulated scales; stipites strong erect, 2–4 in. l., naked or with a few deciduous scales below, castaneous; fronds simple, erect, thickly coriaceous, opaque, naked, glossy, dark green. the underside paler, 2–3 ft. l. 2½–5 in. w., tapering at the base and decurrent on the stipites, the apex usually acute, entire, cartilaginous-edged; rachis prominent on both sides, light or dark brown, naked or with a few deciduous scales down the back; primary veins oblique, 2–3 li. apart not reaching the edge, slightly flexuose, areolæ immersed, many with free included veinlets; sori copious, large. embossed, 1–2 in. diameter parallel lines reaching from the rachis nearly to the margins, usually confined to the upper half or two-thirds

of the frond, the opposite surface pitted and often with dot-like white scales. Pl. Fil. tabs. 123 and 142.

Common on rocks, banks and trees, in shady or open places, up to 6,000 ft. altitude, infrequent in the lower regions, and abundant in the higher; dispersed throughout the colony. It is readily distinguishable from the next species by its thicker texture and, especially, by the single line of large sori between the main veins. The sori are compital, inserted at the junction of the meshes, not on the free veinlets. I have seen a narrow variety, 1 inch wide, ascribed to Jamaica but amount certain of its authenticity.

70. *P. Phyllitidis*, Linn.—Rootstock strong, ligneous, short-creeping more or less scaly; stipites strong, erect few or many, usually subtufted and crowded, margined and varying from hardly any distinct, from the decurrent sides of the fronds to 6 in. l. stramineous or castaneous, glossy; fronds stiff, erect tapering both ways but more so below, 1–3 ft. l. 1½–3 in., w., generally subcoriaceous, naked, glossy, bright pale or dark-green, entire, the edge thin and cartilaginous; the rachis strong, 4–gonal below, prominently raised beneath, straw or chestnut coloured, glossy, primary veins raised, distinct, oblique, intermediary immersed, areolæ 6–12 serial, all fertile; sori copious, aureofulvous, biserial between the main veins, dorsal or terminal, superficial.—Pl. Fil. ts. 130 & 131. Sl. Herb. p. 41. Eat. Ferns N. Am. pl. 42 *Campyloneuron*, Presl.

a. var. *latum.*—Fronds larger, 3-4 ft. l., 3-4 in. w. chartaceous; margins repand, *Campyloneurum latum*, Moore. Common on trees, banks and rocks in open and shady situations, chiefly in the lower regions but ascending to 3,000 or 4,000 ft. altitude. Very variable in size &c. The smaller and larger states seem to run one into the other differing by the individual conditions of growth. There is a form figured in Plumier, t. 131, gathered by Mr. Sherring at Jericho, Jamaica, and previously by Purdie, in which the top of the frond is repeatedly branched and divaricated in the form of a stag's horn. Another is deeply lacerated or pinnatifid along both margins between the primary veins comb-like. A third is coriaceous, with ovate-lanceolate fronds rounded at the top, 6-8 in. l., the main veins more prominent and the colour dark. The rootstock of the typical plants often forms large masses of fibre, which, for growing orchids and epiph tal ferns in suspended baskets or pots is a very durable substance, and an excellent substitute for peat. All the plants of this group are very closely allied.

71. *P. costale*, Kenze.—Rootstock short, repent, clothed with small brown scales at the end; stipites erect, usually few, subtufted, 2-5 or 6 in. l. brown or stramineous, margined, the tops marked by a slight dilation of the marginal wing where it passes into the frond; fronds coriaceous, ¾-1¼ or 1½ ft. l. 1½-2½ in w., the apex finely acuminate or cuspidate, the base correspondingly tapered, the margins even, cartilaginous edged, thin, slightly repand, the rachis slender, usually stramineous; primary veins slender, immersed, as are also the intermediary; sori minute, dorsal below the clavate summit of the vein, fugacious.—*Campyloneuron immersum.* J. Smith. Seem. Bot. Herald.

Frequent on trees over-hanging rivers among the hills of the eastern parishes; well marked from the last by the slender immersed main

veins, very small fugacious sori, thicker but quite pellucid texture, relatively longer stipites, and the slight dilation of the wings at the base of the frond. This, too, is occasionally furcate.

72. *P. lævigatum*, Cav.—Rootstock slender, free-creeping, the bases of the stipites raised in a single linear series along the upper side, scales dark, ovate—acuminate, reticulated; stipites 2-4 in. l., slender, naked, or with a few deciduous pale reticulated scales, stramineous; fronds ½-1 ft. l.. ¾-1¼ in. w., generally finely acuminate, the base attenuated and decurrent on the stipites, chartaceous, naked, light or dark green, glossy, the margin entire usually repand, thin-edged, the rachis slender, stramineous; primary veins slender, but slightly raised and distinct, oblique, rather flexuose, areolæ immersed, 2-4 serial, containing mostly two free soriferous veinlets each, the intermediary capillary branch usually absent; sori small, dorsal or terminal, occupying most of the areolæ.—Pl. Fil. t. 127 B.

Frequent on wet rocks in river beds among the lower hills ascending to 2,000 ft. altitude, chiefly in shade. The rootstock is prostrate, about as thick as strong cord, dark coloured, reaching a foot or more long. The fronds are borne about a ¼ in. apart in a uniform line and leave at the articulate bases when they fall away peculiar truncate socket-like elevations, which are permanent.

73. *P. repens*, Linn.—Rootstock free, or wide-creeping, as thick as strong cord or a quill, clothed with deciduous dark or pale brown acuminate scales; stipites scattered, deciduously scaly at the base, slender, usually stramineous, 1-6 in. l.; fronds chartaceous, pellucid, glossy, dark or light green, oblong-lanceolate, 1-2 ft. l. 1½-2½ in. w., shortly tapering at the base, the apex mostly acuminate, and often attenuate, rachis stramineous or brown, prominent and rounded beneath, the margins usually uneven and repand cartilaginous-edged; primary veins distinct on both sides, oblique, flexuose, transverse branches also slightly raised, areolæ 6-8 serial, wider than deep, not divided by an intermediary capillary branch; sori pale 2-serial between the main veins, terminal or dorsal.—Pl. Fil. t. 134.

Common in moist forests below 4,000 ft. altitude creeping and trailing on the stems of trees and stones. This is well distinguished from any of the other species by the free or wide-creeping rootstock, the more or less distant fronds, relatively wider apart sori and primary veins. Generally the margins are sinuate-repand, and the texture hardly thicker than membrano-chartaceous.

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THE GRAPE INDUSTRY.

By W. Cradwick, Superintendent of Hope Gardens, being notes read at the Kingston Horticultural Society's Meeting.

I do not intend to occupy your attention to-night for any length of time but simply and as briefly as I am able to describe the methods which we have practised in carrying our vineyard at Hope so far; and to put before you my opinion on the merits or demerits as the case may be of those methods.

Many of the vines which are now growing at Hope were not raised by me but were large plants transferred from another vinery;—this as results have shown us, is one of the least satisfactory methods of establishing a vinery.

When it was decided that grape growing was to be taken up at Hope, the first thing which naturally claimed attention, was the position in which they were to be grown.

The first indispensable qualification for the site of the vinery was that it should be where the vines would receive all the sunlight possible; the next was that it should be in such a position that the roots of trees should not penetrate into the snug place I contemplated preparing for the roots, and so rob them of the store of plant food which I intended to place at their disposal.

I finally decided on a spot which after cutting down a good many trees was without shade, I then dug a big trench between my embryo vinery and some other trees to prevent their roots from travelling into it,—and it really is astonishing how far the roots of even moderate sized trees will stretch, when food and moisture are to be their reward.

For the accommodation of the roots of my vines I dug a trench four feet wide and four feet deep, taking care, as it was being done, to separate all the good alluvial soil which was found on the top, from the gravel of which three fourths of the removed soil consisted; the top soil I returned to the bottom of the trench, the deficit caused by not returning the gravel was made good by the addition of other good alluvial soil and a cartload of manure added to every four feet of the border. In the border thus prepared, we planted our vines five feet apart. The planting was done in the spring of 1895: of the large vines which we planted some were plants of three years old, the others being younger,

some not more than a year old. Most of the older vines grew very indifferently, many of the young ones were cut down to within a foot of the ground, and some of these made as much as forty feet of growth during the year. Most of these vines bore fruit this year and next year should be capable of carrying a good crop.

But the young vines which I have raised at Hope from cuttings since we started our vinery, are I consider, likely to prove far more satisfactory than any of the plants which had attained a large size and were then removed to Hope.

I need not trouble you with details as to the methods employed in raising young grape vines as you can buy them at Hope for a penny. But when you procure a young plant, be sure that it is very wet at the roots before you attempt to remove it from the bamboo pot. Before you send for your vine you will of course have properly prepared the place in which you intend it to grow.

Be sure you do not attempt to shake it out of the bamboo joint, but take one of those everlastingly useful cutlasses and split the bamboo from bottom to top on both sides; so that when you take it in your hand, the young plant lies in one half of the bamboo and the other half can be lifted off. Be careful you do not put the young plant too deeply into the ground. If you bury the soil in which it was growing in the bamboo pot half an inch below the surface of the soil that will be quite sufficient. Put the soil lightly round the young plant, pressing it only a little with the hands, and then water it well, the action of the water will cause the soil to settle down round the young plant. In putting out any young plants it is necessary to be careful not to make the soil too tight, for if the soil is pressed down too firmly, it hinders the freedom of root action without which satisfactory growth cannot be made. For the first year a good strong straight stick is all that is needed in the way of arbour. To this stick the young vine can be kept tied, taking great care not to break the young point. Try to make the young vine grow as long as possible. Do not however allow the vines to make long side shoots: these should be stopped at the second joint: and every time they make new growths, as they will, from the end of the pinched back growths, they should again be stopped. By this system during last year we grew plants of Foster's Seedling and Muscat of Alexandria from single eyes 20 feet in length.

These plants at the end of February this year were cut down to the gronnd, this being the plan always adopted by grape growers in England, resulting there beyond doubt in the production of a stronger vine than is produced by a plant which has not been cut back. When the vines again commenced to grow they were treated exactly the same with regard to the stopping, but on account of the much heavier and longer canes which the vines always make the second year, provision had to be made to train them horizontally. This was done by putting two strong sticks five feet in length in the ground twelve feet apart, and with pieces of wire fastening another stick to them at the top. Along the rail thus constructed the vines were trained. As they covered one rail, another was added and the vines grown as long as possible: nearly the whole of the plants so treated have already grown to a length of 20 feet and over. The older vines have been provided with an arbour which for simplicity and cheapness is, I think, hard to beat.

Four stout cashew posts were inserted into the ground four feet apart; a piece of 4 by 4 pitch pine scantling fastened on the top of this served as an end for the arbour; a similar erection was made 25 feet from the first, from one to the other wire was stretched 18 inches apart. The front of the arbour is 4 feet 6 inches high and the back six feet this giving a nice slope; across the wires thus stretched the vines are trained in exactly the same way as they were over the sticks, except that they are trained parallel with the sticks and the opposite over the wires. At the first time of pruning the plants which had made a cane after being cut back to the ground, all the side growths were cut off close to the main cane, a stronger growth being secured from the large bud which is always present at the base of the first lateral growths than from the first lateral growth itself. With the older plants I tried various lengths of pruning the lateral growths, some were pruned back to within two or even one eye of the main growth, some were left four, five and even six joints in length. This I did as I had frequently been told that the close system of pruning, as practised in English hot houses could not be carried out with success in Jamaica, but as far as can be seen at present it did not make the slightest difference in any way. What the effects on the vines may be next year I do not venture to predict.

I have said nothing about watering, but at Hope it would be folly to attempt to grow grapes unless they can be well watered. We water thoroughly twice a week, and if by any chance this was neglected the effects of the neglect could be noticed at once. Although growth did not stop entirely, the rapid rate of growth was checked. As an instance of how rapidly grape vines will grow, I may mention that a cut back plant of Gros Colmar last year grew 23 inches in eight days.

The question of how to grow the vines has been effectually solved, the production of fruit however is not so easy; but will I think have to be solved by the selection of suitable varieties. Nearly all the best European varieties can be made to produce fruit, but the question of ripening the fruit properly is still largely a problem.

A properly ripened bunch of grapes is one on which every berry is ripened at one time. Of the white grapes which we have grown I think that the Muscats are the only ones worth growing to any extent, these ripen up easily and uniformly.

We have grown other white grapes the best of which are Raisin de Calabre and Foster's Seedling, but neither of these can be compared to the Muscat, either for quality or for productiveness. Another great point in favour of the Muscats is that they require very little thinning, a most tedious process with most varieties. Black grapes are not favourites in Jamaica for what reason I cannot tell, except perhaps that with nearly all the black grapes about five times more berries grow on each bunch than can possibly find room to grow to maturity thus necessitating a lot of thinning. If this is not done and at exactly the right time the bunches are spoiled. Some Black Hamburghs which we pruned at Hope in November last ripened some very nice bunches in April this year; these were exhibited at Dr. Morris' lecture at the Collegiate Hall. This variety however gives us a lot of trouble; mildew growing on nearly every bunch.

Black Hamburgh is perhaps the finest flavoured of all the black grapes.

Black Alicante has borne fairly well, producing nice bunches of very fine dark coloured berries of fairly good flavour, but the thinning is the bugbear with this variety.

Gros Colmar that most showy of all grapes (although it never is as good as it looks) has proved a regular fraud. It puts out the most promising looking bunches, which grow and swell up in the finest style imaginable, until just as it commences to colour, the berries begin to crack and fall off, until, by the time they are ripe, often only six or eight berries will be left hanging on a bunch which had it ripened properly would have weighed two or three pounds. We have a great many more varieties under trial at Hope amounting to over 30 in all, in these we hope to be able to find a variety suited to Jamaica but of course we do not expect to be able to find one which will grow without some trouble. I hardly think we are likely to find a white grape better suited to Jamaica than the Muscat, but I do trust we shall find a good black of easier culture thad any of those tried With reference to the grapes which I have seen growing in Manchester and St. Elizabeth; the distressful savannahs at the back of Alligator Pond, and on to Lititz seem to be most admirably adapted for grape growing. A black grape which I do not recognise, growing into magnificent vines in an incredibly short space of time, and producing bunches up to six pounds in weight, I did not see a really properly ripened bunch as none had been thinned, and so only about half the grapes were eatable, but this of course could be easily remedied especially as the grape mentioned really does not set so very many more berries than could be ripened. The berries in some cases were really magnificent being large and of a fine black colour. The soil on the Savannahs is a curious red sandy loam, which on the surface gets as dry as ashes, but never hard, and even after a prolonged drought is quite moist a few inches below the surface. In the whole of the Savannah country which I went over I did not see a single white grape, but in the Bluefields district of Westmoreland Muscats grow and ripen splendidly, and nearly all the year round, but most of the black grapes do not thrive, this part of the island being much too wet.

COCCIDÆ, OR SCALE INSECTS.—XI.

By T. D. A. Cockerell, Entomologist of the New Mexico Agricultural Experiment Station.

Genus *Pinnaspis.*

(68.) *Pinnaspis pandani*, Comstock. (The Pandanus Scale.)

Diagnosis.—A very small light brown or reddish-brown mussel-shaped scale, found in great quantities on the leaves of plants it infests. Under a miscroscope it is seen that the median lobes of the insect are closed together as in *Chionaspis minor.*

Distribution.—Common in Jamaica, and especially in Trinidad. Also found in Grenada, by Mr. Broadway, and in Barbados and British Guiana. It is a hothouse species in the United States and Italy; but it seems not to occur in those parts of Asia and Australasia which have been examined for Coccidæ.

Food-plants.—Originally found on *Pandanus* by Prof. Trelease, in the Harvard Botanic Garden. Del Guercio reports it from *Pandanus utilis.* It occurs on *Pandanus* in the Trinidad Botanic Gardens, in company with *Ischnaspis filiformis.* In Jamaica, I found it on coconut palm in the grounds of the Jamaica Institute; and Mr. E. J. F. Campbell found it on *Dracaena* in Castleton Gardens. From Barbados, Mr. A. C. F. Morgan reports it on coconut palm; and he received it on *Areca lutescens* from the Royal Botanic Society's Gardens, and on *Dictyospermum album* from Trinidad. The Grenada specimens are on *Anthurium crystallinum.* Additional food plants in Trinidad are *Areca catechu*, *Pinanga kuhlii*, *Heliconia Bihai*, and "Balizier."

Destructiveness.—It has not attracted much attention in Jamaica, but in Trinidad Mr. Hart says it "is a great pest on palms which are natives of a cooler climate than ours."

Varieties.—Some specimens found in Jamaica are large and more strongly coloured than usual. A distinct variety (var. *albus.* Ckll.) occurs in Trinidad, having a white scale.

Enemies.—It is attacked by a parasitic fungus in Trinidad.

Note.—Mr. Morgan has expressed the opinion that this is a synonym of *P. buxi* (Bouchi), which occurs on *Buxus sempervirens* in Europe. It is quite probable, however, that the two species are distinct, though closely allied.

(69.) *Pinnaspis bambusæ*, Ckll. (The Bamboo Mussel-Scale.)

Diagnosis.—Small pale horn-coloured mussel-shaped scales, inclined to be tricarinate, on stems of bamboo.

Distribution.—Only known from Jamaica; it was discovered on pieces of bamboo-stem used for flower-pots at Hope Gardens.

Food-plants.—Bamboo only.

Destructiveness.—Not complained of, but from its abundance on the stems it must be harmful.

Enemies.—It has a chalcidid parasite.

Genus *Fiorinia.*

(70.) *Fiorinia fioriniæ*, Targioni—Tozzetti. (The Ridged Scale.)

Diagnosis.—An elongate yellowish-brown scale, very small, distinctly

ridged; the second skin, small in other species, here forms almost the whole of the scale.

Distribution.—Dr. Sinclair found it near Montego Bay, Jamaica, on leaves of coconut palm. Mr. Morgan received it, also on coconut, from Barbados. It is a hothouse species in Europe and the United States. Maskell reports it from New South Wales. Mr. E. E. Green has recorded it (as *F. palmæ*) from Ceylon. Mr. Alex. Craw has found it on camellias from Belgium and Japan.

Food-plants.—Coco-nut palm, *Livistona, Leptospermum*, camellia, *Areca aurea, Phytelephas macrocarpa, Cycas revoluta* and *Kentia.*

Destructiveness.—Not usually very abundant, but destructive when it becomes so.

Varieties.—Under the above name are included some varieties, which may possibly be distinct though allied species. Comstock thought the form he found on camellia was a distinct species, and named it *F. camelliæ*, but it is generally admitted now that he was mistaken. Mr. Green also described the Ceylon form as new, but he no longer considers it distinct. The most distinct variety I have seen was crowded on the under side of a leaf of *Camellia japonica* from Baton Rouge, Louisiana, sent by Prof. Morgan. In this the female scales seemed a little larger than usual, and were dark brown, much darker than those ordinarily found on palms; the middle of the scale became actually black, while the ends were a red brown. There were numbers of male scales with them, white with a slight median keel and very pale exuvia. I found an orange-yellow male with white wings. This does not seem to be quite the same as Comstock's *camelliæ.*

Genus *Ischnaspis.*

(71.) *Ischnaspis filiformis.* Douglas (The Black-line Scale.)

Diagnosis.—The most easily recognized of scales, appearing as a short black line on the leaf it infests. It frequently occurs in numbers giving the leaves a very odd appearance.

Distribution.—It seems to be very abundant in Trinidad; it is also found in Jamaica, Antigua, Grenada, South Australia, Japan, British Guiana and in hot houses in Europe and the United States.

Food-plants.—Various palms, *Dictyospermum, Strychnos, Myristica*, Mango, *Pandanus, Cycas, Monstera*, &c.

Destructiveness.—Not usually complained of, but in Trinidad Mr. Hart says it "is a great trouble to us on *Cycas* and several palms and aroids."

Note.—M. Simon has applied the name *Ischnaspis* to a genus of spiders from St. Vincent. Our genus has priority, and a new name will have to be given to the spider-genus.

Genus *Aspidiotus.*

This genus includes the small round usually more or less flat scales so common almost everywhere. It is very numerous in species.

(72.) *Aspidiotus sacchari.* Ckll. (The Sugar-cane Aspidiotus.)

Diagnosis.—Scale white tinged with greyish, or rather a kind of pinkish brown. Exuviæ darker, first skin brown, second orange.

The insect itself is very pale yellowish, with a slight pink tinge.

Distribution.—Discovered March 1893 in Mr. Streadwick's Marine Garden, Kingston, Jamaica. Not yet found elsewhere.

Food-plant.—It occurs on the culms and sheathing bases of leaves of Sugar-Cane.

Destructiveness.—No good opportunity has occurred to form an estimate of this.

Parasite.—It has an undetermined parasite.

(73.) *Aspidiotus hartii*, Ckll. (The Yam Aspidiotus.)

Diagnosis.—Scale much like *sacchari*, with the same curious pinkish-brown tint. The first skin is shining pale straw colour. When the scales drop off the yams, they leave conspicuous white marks; so that, to use a hibernicism, their presence is most noticeable when they are not there

Distribution.—Only found in Trinidad.

Food-plant.—On roots of yam, abundant.

Destructiveness.—Mr. Hart says it does not appear to injure growing plants; I should suppose it might interfere with the sale of the yams.

Variety.—The variety *luntii*, Ckll., was found by Mr. Lunt in Trinidad on the stems of some plant. The female, under the microscope, does not show the groups of ventral glands of the type, from which we infer that it is viviparous (ovoviviparous), the type being oviparous.

(74.) *Aspidiotus biformis*, Ckll. (The orchid Aspidiotus.)

Diagnosis.—A round dark brown or reddish brown female scale, with a small elongate-oval male scale. Sometimes the scales are almost black; they have a granular surface.

Distribution.—Rather common on cultivated orchids in Jamaica and Trinidad. Lately Mr. Alex. Craw has found it on an orchid from Central America,—the precise locality unknown.

Food-plants.—Orchids; *Oncidium Sprucei, Odontoglossum grande, Epidendrum, Cattleya Bowringiana.*

Destructiveness.—Certainly injurious to choice orchids.

Varieties.—While this is a very distinct species, it includes two varieties, which I have named *Cattleyæ* and *odontoglossi*. The former is noticeable for its black exuviæ; the latter has the exuviæ also black, but covered by pale secretion.

Note.—An account of this species, with figures, will be found in *The Gardeners' Chronicle* for May 6, 1893, p. 548.

(75.) *Aspidiotus palmæ*, Morgan and Ckll. (The Coconut Aspidiotus.)

Diagnosis.—A small rather convex pale brown scale, with the exuviæ black, and on one side of the centre. The female has grouped ventral glands, which are wanting in *A. rapax*, which has a similar looking scale.

Distribution.—Found in Jamaica and Trinidad.

Food-plants.—Leaves of coconut palm and banana. I once found a few scales on lignum-vitæ trees in Kingston, Jamaica, but they were close to some coconuts.

Destructiveness.—It seems to do no serious harm.

Parasites.—It has an undetermined parasite in Jamaica.

Mesilla, New Mexico, U.S.A., March 1, 1897.

HOW TO GATHER LOGWOOD SEED.

By T. H. Sharp.

February and March are the best months to gather the seed in Jamaica.

Fully matured trees should be selected, young trees and old trees avoided. To avoid being deceived carry with you a small sample of the wood you require; scrape, wet and compare it with the interior of the tree before gathering seed. Bore with an auger or chip with an axe about three feet from the ground until you have obtained a portion of the interior and satisfied yourself that the colour answers the sample you desire. See that the appearance of the seed-pod on the tree is not quite dark-brown, and bone dry; but is light-brown and half dry: that is to say that the seed-pods are fully matured and just getting dry.

Clear all weeds from under the tree, spread a large circular calico sheet on the ground. Climb the tree, or take a long stick with a hook at the end and shake the branches gently. A large quantity of seed will fall, examine it, and you will find a large proportion immature, also insect-eaten, and empty pods, dust, rotten twigs, &c. Gather up the sheet and throw away the whole of the stuff. Spread the sheet again, climb the tree and after selecting the branches that seem to have the best seed, chop them with a sharp cutlass partially through, so that they bend down within a foot or two of the sheet. About one-third of the branches on the tree will be found to have good seed and are generally midway up, and if these are lopped half way out to the end no harm will be done to the tree. Then with a coarse glove on your hand, stand on the ground and strip the seed-pods off the branches so that they fall on the sheet.

Remove the seed to some cool, well ventilated place, and spread them out for three or four days so as to avoid fermentation. When they are cured and cool, give them a few hours' sunning. Rub through a sieve and winnow; then keep the seed in an open tray for two or three days, winnow a second time, put them in dry bottles, shake well, and fill to within an inch of the cork, put in a bit of cotton, then about a teaspoonful of camphor, cork well and seal.

Seed gathered like this two years ago by me are still in good order.

Keeping seed in the pod after being gathered facilitates the destruction by insects which harbour in the pods.

LEGUMINOUS PLANTS FOR GREEN MANURING AND FOR FEEDING.

By E. W. Allen, Ph. D., Assistant Director of the Office of Experiment Stations, U. S. Department of Agriculture.

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Green Manuring.

Green manuring, or ploughing under green crops raised for that purpose, is one of the oldest means of improving the fertility of the soil. It was advocated by Roman writers more than two thousand years ago, and from that time until now it has formed a most important resource of the farmer, especially where the supply of barnyard manure is insufficient. Its advantages are many. The more striking are that it furnishes the surface soil with a supply of the fertilising materials needed by crops, increases the humus, and improves the physical qualities and the tilth of the soil. As a humus-former green manuring stands next to barnyard manure.

By means of green manuring, land which is practically barren may be brought up to a state of fertility where it will produce profitable crops. As a single instance of this may be mentioned the experiments carried on by the Michigan Experiment Station on the "Jack-pine plains" of that State. In 1888 experiments were undertaken on the light sandy, almost barren, soils of these plains. Green manures were used mainly, supplemented by cheap fertilisers. In three years marked improvement was evident, not only in the physical character of the soil but also in the increased yields of various crops.

Again, green manuring may be used to take the place of more expensive fertilisers and manures on soils already under cultivation. It is in this latter use that it finds its widest application.

There has been much speculation as to the manner in which the crops commonly used for green manuring could gather such large quantities of fertilising materials. It will be remembered that the principal fertilising ingredients required by plants are nitrogen, phosphoric acid, and potash. These are each and all more or less essential to the healthy growth of crops. Consequently they are applied to the soil in the form of commercial fertilisers and other manures. In attempting to explain how the fertility of the soil is maintained by green manuring it has been said that plants with long roots, like clovers, feed deep down in the soil or subsoil on materials beyond the reach of surface-feeding plants; and that when the tops of these plants die down and are mixed with the surface soil they enrich it much the same as an application of barnyard manure. This is undoubedly true, but it fails to explain how such large quantities of materials can be obtained, especially when clover is grown continuously for a number of years. The question has finally been solved by one of the most interesting and important discoveries yet made in agricultural science. It has been found that certain plants can feed upon the nitrogen in the atmosphere and store it up in their tissues as they grow. They take their phosphoric acid and potash from the soil, but they obtain their nitrogen very largely from the air. Hence they draw from the air a material necessary to the growth of crops which in the form of commercial fertilisers,

as nitrate of soda, ammonium sulphate, dried blood, etc., is paid for at the rate of from 15 to 20 cents a pound.

HOW PLANTS GET NITROGEN FROM THE AIR.

The air we breathe is about four-fifths nitrogen and one fifth oxygen. We use the oxygen in breathing but discard the nitrogen. It has been regarded merely as a material for diluting the oxygen, which would be otherwise too strong for our use. All attempts to economically render this nitrogen of the air available for plant food, by chemical means, have been unsuccessful. Recently it has been discovered that the so-called leguminous plants—clovers, peas, beans, lupines, vetches, etc.—can take up this nitrogen of the air, and can grow without being manured with nitrogen if manured with phosphoric acid and potash.

The manner in which this nitrogen assimilation takes place has been carefully and patiently studied by scientists, and although the details are not fully understood the primary cause has been found. It is believed that plants are enabled to get this nitrogen through the activity of the lower forms of life, bacteria or microbes, which can only be seen with the aid of a powerful microscope. These organisms live in the soil and are to be found where leguminous plants have been grown. They produce or cause the plant to produce little nodules, or tubercles, on the roots It is through these tubercles that the plant gets its atmospheric nitrogen. The air enters the soil by the numerous pores or openings in it, which are produced by ploughing, cultivating, and working the soil, by the decay of rootlets, by earthworms, etc. By just what physiological processes the nitrogen assimilation takes place is a question still in dispute among scientists. It is sufficient for practical purposes to know that nitrogen is taken up from the air by the growing plant, directly or indirectly; and that this nitrogen assimilation takes place as a result of the life of bacteria. It is a peculiar fact that few, if any, root tubercles are formed when leguminous plants are manured with nitrogen; the plants must first hunger for nitrogen before the tubercles are formed, and the presence of tubercles indicates that the plant is taking nitrogen from the air.

Now, curious as it may seem, there appear to be different forms of bacteria for different kinds of plants. Hence it sometimes becomes necessary to provide crops with the necessary bacteria before they can use the nitrogen of the air. This is done by applying a light dressing of soil in which the kind of plants it is wished to grow have been previously grown. This is called soil inoculation. It is sometimes necessary in growing a crop on a piece of land for the first time in several years. Suppose, for instance, that peas which had been sown on land manured with phosphates and potash but without nitrogen failed to grow luxuriantly. If the other conditions were favorable, the inference would be that bacteria of the right kind were lacking in the soil, and a light dressing of soil in which peas had previously been successfully grown might be applied. Such treatment as this has been repeatedly tried with success on a large scale.

These discoveries throw a new light on green manuring and on the plants best adapted for green manuring. They recommend it more highly than ever before as a soil renovator and a cheap means of main-

taining the fertility of a soil. They show that while both leguminous and non-leguminous plants enrich the soil alike in humus-forming materials, in proportion to the size of the crop, they differ in respect to the source of their nitrogenous materials. While non-leguminous plants derive their nitrogen supply almost exclusively from the soil, leguminous plants may take theirs largely from the air. Consequently, if spurry, buckwheat, mustard, etc. (non-leguminous plants), are grown on the soil and the crop ploughed in, the soil is not materially enriched in nitrogen; the process is simply returning to the soil all the nitrogen which the crop took from it. But since leguminous plants may derive the larger propotion of their nitrogen from without the soil—that is, from the air—their use for green manuring actually enriches the soil in nitrogenous matter.

It will thus be seen that by green manuring with leguminous crops it is possible to manure the soil with nitrogen from the air, a free and inexhaustible source, and thus avoid buying fertilisers containing much nitrogen. This greatly lessens the expense for commercial fertilisers, for nitrogen is the most expensive element the farmer has to buy. As stated above, it costs from 15 to 20 cents a pound, while potash and phosphoric acid cost only 5 to 7 cents, or even less. Although grains, grasses, corn, cotton, root crops, tobacco, etc., can not use the nitrogen of the air, green manuring enables them to benefit by it indirectly.

SOME CROPS FOR GREEN MANURING.

Among the leguminous plants more commonly used for green manuring in this country and in Europe are cowpea, alfalfa, clovers, melilotus, serradella, lupines, vetch, and horse bean. Some of these are described below.

Cowpea.

The cowpea is widely used as a green manure in the Southern States. According to the North Carolina Experiment Station, "the cowpea, being a tender annual, shonld always be sown in the spring. It will give a good yield sown as late as July 1, but the earlier it is sown after danger of frost is passed the heavier the yield. The pea is usually sown broadcast at the rate of 2 bushels per acre and ploughed or harrowed in. The cowpea is not affected by heat, and is less sensitive to drought than any of the clovers."

Experiments have shown that cowpeas respond readily to applications of potash and phosphates, and are able to derive their nitrogen very largely from the air. Inasmuch as cowpeas are large gatherers of nitrogen, and also secure considerable amounts of potash and phosphoric acid through their extensive root system, which reaches down to the subsoil, they have a high fertilising value. How to get the greatest benefit from the fertilising constituents of cowpeas is one of the problems on which the experiment stations are working. If the cowpeas are ploughed under in the fall and the ground left bare until spring a large share of the nitrogen will be leached away. By sowing wheat or rye after the cowpeas are plonghed under part of this loss may be avoided. If the vines are cut and allowed to lie on the ground during the winter the nitrogen is rapidly lost. In an experiment at the station in Ala-

bama it was found that vines gathered in October had from 1.45 to 2.62 per cent. of nitrogen, while if left on the ground until January they had only about 0.70 per cent., *i. e.*, they lost two thirds of their most valuable fertilizing ingredient.

Experiments at the Louisiana station show that 1 acre of cowpeas, yielding 3,970.38 pounds of organic matter, turned under, gave to the soil 64.95 pounds of nitrogen, 20.39 pounds of phosphoric acid, and 110.56 pounds of potash, of which at least 8.34 pounds of nitrogen, 4.43 pounds of phosphoric acid, and 18.1 pounds of potash were furnished by the roots. Analyses made at the South Carolina Station show that cowpea hay contains 1.42 per cent. of potash, 0.39 per cent. of phosphoric acid, and 2.71 per cent. of nitrogen. Cowpea roots contained 1.19 per cent. of potash, 0.28 per cent. of phosphoric acid, and 0.94 per cent. of nitrogen; the roots and stubble, two months after the crop was harvested, contained 0.83 per cent of potash, 0.26 per cent. of phosphoric acid, and 1.35 per cent. of nitrogen. Experiments elsewhere showed that the vines from a given area weighed six times as much as the roots, and were 8⅓ times as valuable for manure.

Cowpeas and melilotus have given good results as green manure on the canebrake lands of Alabama. "Before the land was sowed in melilotus and cowpeas it was not considered worth cultivating. This season (1890) it produced as fine a crop as the best lands of the station highly fertilised."

Alfalfa

Alfalfa or lucern has long been cultivated in Europe, and is grown quite extensively in some of the Western and Southern States. It seems probable that it may be introduced with advantage into many parts of the Southern States east of the Mississippi, and over a wide tract of the more arid regions of the Southwest. Under favourable conditions it will live from eight to fifteen years, and does not run out as clover does. It has been grown successfully for seven years at the experiment station at Geneva, N. Y., but in recent experiments on 30 farms in different parts of Vermont it was very largely winterkilled. While a Southern climate is more favourable to alfalfa, numerous experiments have shown that it will do well in many localities in the Northern States, and when established will produce from three to five crops each season for a number of successive years. Alfalfa is said to be especially adapted to dry climates, and withstands drought much better than ordinary clovers. For this reason it is largely relied on in Colorado and California, especially where irrigation is used.

The value of alfalfa for green manuring has been quite thoroughly studied by the New Jersey Experiment Station. Seed was sown broadcast at the rate of 15 pounds per acre. A fertiliser containing phosphoric acid and potash with a little nitrogen was applied. It appears from these studies that alfalfa derives nitrogen from some other source than the soil, and draws potash through its long roots from the deeper layers of the subsoil. In three years 90 pounds of nitrogen per acre was applied in the fertiliser, and the crops harvested in that time contained 912.8 pounds of nitrogen per acre. The fertilising materials contained in the crops harvested in four years are shown in the following table:

Fertilising ingredients in alfalfa during different seasons.

Year.	Pounds per acre.		
	Nitrogen.	Phos horic acid.	Potash.
1886	261.6	39.6	203.5
1887	253.6	45.7	286.9
1888	299 2	52.4	292.2
1889	360.0	63.0	255.5

The average of the above table is 304 pounds of nitrogen, 50 pounds of phosphoric acid, and 260 pounds of potash a year. These amounts would be furnished by a dressing of 1,900 pounds of nitrate of soda, 500 pounds of muriate of potash, and 300 pounds of South Carolina superphosphate. The phosphoric acid and potash were naturally derived from the soil. The 300 pounds of nitrogen would cost in the form of nitrate of soda, at the present low price of 15½ cents a pound, $46.50.

Red Clover.

Red clover has been cultivated for centuries It succeeds best in a temperate climate not deficient in moisture. In the central and eastern part of the United States it constitutes one of the most important han crops. Though not generally grown in the Gulf States it succeeds oy the strong clay lands and black prairie soil of the South It may be grown as far north as Minnesota, but frequently does not thrive in newly settled sections. It has been successfully grown all over Nebraska, where it is recommended for early pasture as well as for hay, and where it withstands drought. It has proved valuable in South Dakota. Most of the experiment stations give favourable reports of this plant In Nevada, however, without water the growth is light.

As a green manure it is perhaps more extensively used in the United States than any other plant. Twenty pounds of seed per acre is the quantity usually recommended. The seel is frequently adulterated with weed seed. At the Mississippi Station light-c loured and dark seed germinated alike in the ground. Clover is sown broadcast. In cold climates spring sowing is customary. The Connecticut Storrs Station recommends sowing after grain in the latter part of July, in order to secure an early crop the next season. In the South seeding in September or October and in February is successful. In Kentucky seed sown between February 2 and March 1 nearly all germinated

Studies of the root system of red clover grown at the Minnesota Station showed that the amount of roots and the depth to which they penetrate vary greatly, depending on the character of the land. In a favourable soil a plant one month old had a root extending 7 inches into the ground; at two months old it had reached a depth of 2 feet; at five months its length was 5 feet 8 inches. The root development is most extensive on drained land. The stand is also better on drained than on undrained soils.

Crimson Clover.

Crimson clover, also called scarlet clover and Italian or German clover, grows from 1 to 2 feet high, with flower heads from $1\frac{1}{2}$ to 2 inches long and of a bright crimson colour. Though not generally grown in the North it made a growth of 26 inches at the Maine Station. It thrives on soil too light for other clovers. In the South it is valuable on non-calcareous, sandy, or light clay soils. It has been highly recommended for green manuring and its value for that purpose has been studied especially by the Delaware Experiment Station. That Station reported that in 1891 2,340 acres of crimson clover were grown in Delaware, 1,277 acres being used for green manuring. It is sown both in the open fields and in orchids. The quantity of seed used depends upon the aims of the sower, varying between 5 and 15 pounds per acre. It is also sown among corn, and with a broadcasting machine 4 acres per hour can be seeded. It may be grown either as a winter crop, covering the soil during September, October and November, or as a summer crop. As a winter crop it may either precede or follow the Southern cowpea vine. In Delaware a very large acreage of field corn is sown to crimson clover immediately after the cultivation of the corn is finished for the season.

Crimson clover is sown in Delaware the latter part of July or during August. In the South the seed may be sown from August till the middle of September or even later in extreme southern latitudes. It is important that considerable growth should be made before winter. On the other hand, to obtain a good stand, one must wait for a suitable season. It is not necessary to prepare the land especially for the clover crop, but the seed may be sown in the fields of cotton, corn, or vegetables immediately after the cultivation and without covering. If clover is the only crop a light brushing or rolling is in order. The seed may also be sown among the vines of a pea crop. Crimson clover begins its growth as the peas die, and these two renovating crops supply a very large amount of organic matter to the soil.

Failure to secure a stand of crimson clover is frequent, due sometimes to the seed and sometimes to the season. The newly germinated plants are easily killed by a scorching sun. On stubble land a catch may be secured by harrowing deeply and then sowing the seed and rolling or harrowing lightly.

In Delaware crimson clover can be cut for hay or for silage early in May. In the South it blooms in April. A yield of from 1 to 2 tons of excellent hay may be secured from very thin land. The hay is taken off in time to allow the use of the field for other summer crops. In Delaware some farmers, while ploughing under the green crop in orchards, turn the furrows so as to leave the heads of clover above ground. These heads bear seed and thus afford a stand the next year. In cutting for hay in orchards other farmers leave strips of uncut clover along the rows of trees. From these strips the seed is scattered for the next year's crop.

Crimson clover may follow grain or grass as well as cultivated crops. After cultivated crops it usually makes a good catch with slight expense. Orchards on thin soils may be benefited by ploughing in crimson clover for several years in succession. On rich soil and for some crops it is possible to incorporate too much organic matter with

the soil. Crimson clover leaves the land in good condition for a crop of cotton, corn or vegetables. It has been found an excellent substitute for nitrate of soda in growing sweet potatoes in Delaware.

At the Delaware Experiment Station crimson clover yielded at the rate of 13 tons 556 pounds of green material per acre (exclusive of roots and stubble), containing 131 pounds of potash, 35 pounds of phosphoric acid, and 115 pounds of nitrogen. As a source of nitrogen for fruits, field crops, and vegetables it has given highly satisfactory results, in some cases surpassing nitrate of soda.

The following illustration of the result of using crimson clover for green manuring is from a recent report of the Delaware Experiment Station:

Seed of crimson clover costing $1 per acre was sown in a corn field near Newark, in 1891, immediately after the last cultivation of the crop. The clover passed out of blossom during the first week of June, 1892. A test made at that time indicated that the green crop then standing weighed 8 tons 600 pounds per acre. It was ploughed under on the 5th instant; Mastodon seed corn was planted on the 7th. An adjoining plat upon which tomatoes had been grown in 1891, and upon which no clover had been seeded for many years, was also planted with the same variety of corn on the 7th instant. A portion of this corn on the tomato plat was top-dressed with nitrate of soda, 100 pounds per acre, costing $1. The tomato plat yielded 24 bushels of shelled corn per acre, the tomato plat with nitrate of soda yielded 30 bushels, and the plat manured with crimson clover yielded 48 bushels.

Eight tons 600 pounds of crimson clover from seed which cost $1 per acre added 24 bushels to the corn crop. One dollar invested in nitrate of soda and used as a top dressing added 6 bushels to the corn crop. Hence in this case $1 invested in clover seed returned four times as much as $1 invested in nitrate of soda. As to the relative amount of labour involved, the sowing of the seed and the broadcasting of the nitrate possibly balance each other. Ploughing down a green crop is doubtless far more costly than ploughing bare ground. This drawback may reduce the abovenamed apparent gain by approximately 25 per cent.

Japan Clover.

Japan clover (*Lespedeza striata*) has been very successfully grown at the North Carolina Experiment Station and is strongly recommended as a renovator of worn soils. At the station it was grown on a very poor stiff clay soil with a light dressing of phosphate. Other clovers, lucern, and serradella, did very poorly on this soil, but the Japan clover presented a most luxuriant appearance throughout the season. The seed is broadcasted at the rate of about 12 ponnds per acre and covered with a smoothing harrow or roller. The seed costs from 12 to 20 cents a pound, and can be bought of most of the larger seed firms. The seed should be sown in the spring after danger of frost is over, as the plant is very tender. Japan clover seems to prefer a moist clay soil, but does well on almost any soil except pure sand, and thrives without fertiliser on exhausted soils. Drought checks its growth for a time, but not seriously.

The North Carolina Station says:

The ability to grow on land too poor to produce even broom sedge, and to crowd out all other plants; its dying each winter and leaving its roots to fertilise the soil; and its possessing the nitrogen-fixing power peculiar to the pulse family of plants, place Japan clover at the head of renovating plants adapted to the climate of Southern States. It is unequaled as a restorer of worn fields, such as are generally turned out to grow up in pines.

Lupines.

The three species of lupines more commonly grown are the white, the yellow, and the blue lupine. The plants are bushy, somewhat woody,

and generally too coarse for good fodder, though they are used in some countries for sheep. The seed is exceedingly nitrogenous and in Europe is used for cattle food. As it contains a bitter alkaloid injurious to animals it must be disembittered before feeding. Kellner's process of disembittering lupine seed consists in soaking the seed in water for twenty-four hours, with frequent changes of water, steaming for one hour, and then extracting for two days, with frequent stirring. In the latter operation the discoloured water is drawn off frequently and fresh water added. Five pounds daily of this disembittered lupine seed may be fed to cows per 1,000 pounds live weight.

Lupines are much used in Europe for green manuring. They thrive on a light sandy soil, make a rapid growth, and produce large amounts of organic materials, which when ploughed into the soil improve it in humus and enrich it in nitrogen. A practice recommended for bringing up very poor soils is to grow a crop of lupine manured with kainit, turn the crop under, and follow it with winter rye manured with Thomas slag phosphate.

In order to derive the greatest possible advantage from the green manuring, the lupines should be sown early in May. By the first half of August, which is believed to be the best time of the year for ploughing under, the seed of the lupine will be nearly or quite formed, and the crop will contain the maximum quantity of nitrogenous matter. Four or better six, weeks should intervene between the plowing under of the lupine and the sowing of the rye.

Under such a rotation a poor sandy soil will gradually improve in humus until the change is perceptible to the eye in the darker color of the soil, and there will likewise be an increase in fertility.

In Europe large tracts of barren waste have been brought into condition for profitable cultivation by green manuring with lupines treated with phosphates and potash salts.

COMPOSITION OF GREEN LEGUMINOUS CROPS.

The following table gives the average amounts of water and fertilizing materials in 100 pounds in a number of green leguminous crops:

Fertilizing ingredients in 100 pounds of green leguminous crops.

	Moisture.	Nitrogen.	Phosphoric acid.	Potassium oxide.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Red clover	80.00	0.53	0.13	0.46
White clover	81.00	0.56	0.20	0.24
Alsike clover	81.80	0.44	0.11	0.20
Crimson clover	82.50	0 43	0.13	0 49
Alfalfa	75.30	0 72	0.13	0.56
Cowpea	78.81	0.27	0 10	0 31
Serradella	82.59	0.41	0.14	0.42
Soja bean	73 20	0.29	0.15	0.53
Horse bean	74.71	0.68	0.33	1 37
White lupine	85.35	0.44	0.35	1.73
Yellow Lupine	83.15	0.51	0.11	0 15
Flat Pea *(Lathyrus sylvestris)* ...	71.60	1.13	0.18	0.58
Common vetch ...	84.50	0 59	1.19	0.70

GREEN MANURING COMPARED WITH FEEDING THE CROP.

In spite of the many advantages of green manuring, there are conditions under which it can not be regarded as a rational and profitable practice. It involves the absolute waste of large quantities of the very best kind of fodder. For this reason green manuring on good soils can only be recommended when the conditions of farming do not admit of the careful preservation of manure. The crops should be fed to animals and the manure carefully saved and returned to the soil. It is in this manner only that the full value of the crop can be secured. By feeding the crop this animal food is saved, and at the same time from three quarters to nine tenths of the fertilising materials (nitrogen, phosphoric acid, and potash) in the crop may be returned to the soil in the manure, if this is properly cared for. Animals need for their nutrition nitrogen, fat, and carbohydrates (starch, sugar, etc.). The nitrogen in foods is in the form of protein (albuminoid materials). It is the same nitrogen which in green manuring enriches the soil. These leguminous crops are unusually rich in protein—far richer than most other coarse fodders. For instance, while hay from grasses contains from 6 to 8 per cent. of protein, red clover hay contains 12.5 per cent. alfalfa hay 14.3 per cent, and cowpea hay 16.6 per cent of protein. If grass hay and corn are fed, such concentrated feeding stuffs as cotton-seed meal, gluten meal, linseed meal, etc, must be fed to make up the supply of protein needed. If leguminous crops are fed, much less grain will be required.

As nitrogen is the most expensive fertilising element, so protein (nitrogen) is also by far the most expensive food element. By feeding the leguminous crops instead of ploughing them under a two-fold result is secured—animals are nourished without buying expensive grain feeds, and the soil is enriched to very nearly the same extent as in green manuring.

Beyond question the nitrogen of the air, which is obtained without cost through the agency of leguminous plants, is best utilised in improving the productiveness of the land and increasing the profits of the farm when it is used in the production of milk and meat and thereby in the production of cheap barnyard manure. What has been said of the nitrogen applies also to the carbohydrates and fats which the plant derives from the carbonic acid of the air. If the crop is fed, the carbohydrates and fat serve to nourish the animal and a portion in turn passes into the barnyard manure, and when applied to the soil has a favourable effect on the humus formation. This is the true economy of material. It is following out the law of nature. Its profitableness will depend upon the price of feeding stuffs in general. The higher the prevailing price of hay and other feeding stuffs the larger will be the profit from feeding the crop rather than using it for green manuring. Let us consider a few examples of the value of a crop for green manuring and for feeding on different kinds of soils.

SERRADELLA ON MEDIUM SANDY SOILS.

Take, for instance, the case of serradella on the better class of sandy soils. This plant does well on medium light sandy soils. It may be sown among winter rye in spring. Under these conditions it produces an unusually luxuriant vegetation which may either be ploughed unde

with good effect on the crop following, or it may be pastured Serradella is an excellent fodder plant and may be fed with none of the danger attending the feeding of lupines. It may be fed either green or as hay or silage. It is eagerly eaten by all kinds of farm animals, retains its palatability and food value up to the end of blooming, and has a very favourable effect on the secretion of milk.

The claim is frequently made, in advocating growing serradella for green manuring, that it is an exceedingly cheap means of securing nitrogen; that with a small expenditure for seed, and no extra labour except that of sowing the seed, a large amount of nitrogen is secured from the air. Admitting this, has not this nitrogen, in the form in which it exists, namely, as portein, a much higher value when used for feeding animals than when ploughed under? If it is a cheap source of nitrogen for manuring, is it not also a cheap source of portein for feeding, especially when three quarters of the nitrogen in the crop is recovered in the manure?

A German authority on feeding and farm management has calculated the matter on a financial basis. Assuming an average crop of 17,600 pounds of green serredella, which is a moderate crop, he finds the nitrogen in the crop from an acre to be worth $11.06. This is taken as the value of the crop for green manuring, as the nitrogen is the only fertilising element not derived from the soil, and the barnyard manure furnishes nearly as much humus as green manuring

The estimated profit from feeding the crop of 17,600 pounds of green serradella to milch cows, when the barnyard manure is returned to the soil, is $23.12. In this calculation every possible expense attending the feeding is taken into account, including care of animals, interest on money, cost of carting the barnyard manure to the land, etc., and allowance is made for the phosphoric acid and potash sold in the milk. The comparison stands then as follows :—

Profit from feeding crop of serradella from 1 acre	$23.12
Value of crop of serradella from 1 acre of green manuring	11.06
Difference	$12.06

This calculation shows the crop of serradella to be more than twice as valuable for feeding as for green manuring.

The above calculation assumed a daily milk yield of 7½ quarts, sold at 2¼ cents per quart. On the basis of only 1½ cents per quart of milk, the feeding value would be $13.52, or still $2.46 higher than the value for green manuring.

GREEN MANURING ON MEDIUM RICH SOILS.

Green manuring on medium rich soils has much less to recommend it than on sandy soils. Although the green manuring of light sandy soils with lupines is often of very great advantage in enriching the soil in humus, this advantage does not hold good in the case of better soil.

There are other plants better adapted than lupines to serve as fallow crops on these better soils. Serradella does well, but as a rule is not to be recommended for a principal crop, and when sown with rye, giving a good yield, it is often so choked out as to amount to very little. But where it can be grown with advantage as a first crop on better soils it must be fed to be utilised to the fullest extent, as pointed out above.

Peas and vetch are especially adapted for fallow crops, and can be recommended for green manuring. But as they are also good fodder plants, all that has been said above regarding this subject applies to them with equal force.

An experiment of interest in this connection was made at the Agricultural Institute at Halle, Germany, in 1891. About 3 acres of land was used which had been in winter wheat in 1890 and in winter rye in 1891. A mixture of 194 pounds of white field peas, 44 pounds of common sand vetch, and 35 pounds of yellow lupine seed per acre was sown August 11. The crop was ploughed under October 28. A good growth had been made and the crop was fitted either for green manuring or for feeding. The yield was at the rate of 8,650 pounds of green material per acre. This contained by analysis 0.575 per cent. of nitrogen, or 49.74 pounds of nitrogen per acre, which at 15 cents per pound gave a value for the crop for green manuring of $7.46 an acre.

In the spring of 1892 white pearl barley was sown on the whole area and also on an adjoining piece not green manured. The crops were harvested August 18, with the following results per acre:

Yield of barley per acre with and without green manuring.

	Grain.	Chaff.	Straw.
	Bushels.	*Pounds.*	*Pounds.*
Plat green manured with peas, vetch, and lupine ...	61.38	366	3,260
Plat not green manured ..	61.48	385	2,908

An effect of the green manuring is only noticeable in the amount of straw, which is larger by about 350 pounds per acre where the mixture of peas, vetch, and lupine had been ploughed in.

The barley crop from the green manured plat contained 68.56 pounds of nitrogen per acre, and that from the plat not green manured 56.6 pounds of nitrogen. This difference of 11.96 pounds of nitrogen is nearly all accounted for by the nitrogen contained in the seed sown on the green-manured plat, so that it may be that on this medium rich soil green manuring was without any effect whatever on the crop immediatly following it. The pea and vetch plants produced root tubercles, and it is probable that had the plants been allowed to fully develop and ripen the effect of the tubercles would have been much more apparent in the amount of nitrogen in the crop ploughed under. But the richer the soil is the larger the proportion of nitrogen which will be taken from the soil and the less from the air. This nitrogen-gathering appears to go on best in a soil deficient in available nitrogen, as already mentioned.

The author estimates the green forage as worth $3 per ton for feeding, which would make the crop worth $13 per acre, or $5.54 more per acre than the estimated value for green manuring.

GREEN MANURING ON SANDY LOAM SOILS.

Compared with the above green-manuring trial on medium rich soil, the result was quite different in a similar trial in 1891 on a sandy loam soil poor in humus, A piece of land which for many years had received

uniform cropping and manuring was divided into two plats of about one fourth acre each. Rye had been grown on both plats that season.

On one plat white field peas were sown in the rye stubble August 15. The other plat was given the same preparatory treatment, but remained bare. Both plats were ploughed November 2. The pea vines had grown to a height of 15 to 18 inches, and a large weighed sample showed that the green crop was at the rate of 3½ tons per acre, containing 37½ pounds of nitrogen.

March 23, 1892, barley was sown on both plats. The green-manured plat received no other manuring, but the other plat received an amount of nitrate of soda furnishing 28 pounds of nitrogen per acre. The barley was harvested August 9. The yield on the two plats was practically the same. The agreement in percentage of nitrogen is equally striking. The total nitrogen per acre in the crop from the green-manured plat was 60.34 pounds, and from the nitrate of soda plat 60.12 pounds. The green manuring, with 37.33 pounds of nitrogen per acre had given a result equally as good in every way as an application of 28 pounds of nitrogen per acre in the form of nitrate of soda. But even with this favourable result there was no financial advantage from the green manuring as shown by this single crop. It furnished 37.33 pounds of nitrogen per acre, which at 15 cents per pound would be worth only $5.60, which would no more than pay for the pea seed used.

ALFALFA AND CRIMSON CLOVER FOR FEEDING.

Suppose that, instead of being ploughed under, the alfalfa grown at the New Jersey Experiment Station, as referred to (p. 156), had been fed to animals and the manure carefully saved and returned to the soil. The total yield of four cuttings during the season of 1889 was about 23 tons of green alfalfa per acre. The value of this crop for fodder at $3 per ton would be $69 as compared with its value of $46.50 for green manuring, and it is fair to assume that some $35 worth of nitrogen would be returned to the soil in the manure. The crop of 13¼ tons of crimson clover reported elsewhere (p. 158) would be worth about $40 for feeding as compared with $17.25 for green manuring. When made into hay crimson clover is an excellent feeding stuff and rivals bran in composition. Instead of cutting the crop it may be pastured to advantage.

COWPEA FOR FEEDING.

A prominent agriculturist in the South says of the cowpea:

> For the production of a nitrogenous food in the shape of a forage crop the cowpea vines are almost without a rival. * * * On an acre of ordinary land this crop will probably produce more digestible food than either oats or corn. The manure resulting from feeding this crop is of the highest value and should be carefully preserved and returned to the land.

At the Rhode Island Experiment Station a crop of 17½ tons of green cowpea forage was harvested. This contained 157½ pounds of nitrogen, which at 15 cents per pound would make the crop worth $23.63 per acre for green manuring. At $3 per ton the 17½ tons would be worth $52.50 for feeding and there would be less than one third of the fertilising ingredients lost in feeding the crop.

What has been said of the above crops applies with equal force to other crops commonly used for green manuring. The matter resolves-

itself into this, that on medium and better classes of soils green manuring is not as profitable as feeding the crop. When the crop is fed the stubble and roots are left to the soil,, and they together with the manure enrich the soil in fertilising materials, and in humus to very nearly the same extent as ploughing the whole crop under. With the exception of perhaps one fourth of the fertilising materials, the soil shares all the advantages to be obtained from green manuring when the crop is fed and the manure preserved. More labour is involved in feeding but in return more milk and more beef are made, or the purchase of expensive grain is largely avoided.

In a rational system of farming not a single pound of protein which can be used as food for stock should be ploughed into the soil. Of course there are conditions under which green manuring is to be recommended in preference to feeding the crop, and unfortunately such conditions prevail at present over a considerable part of this country. Unless the manure is carefully collected and preserved the advantages from feeding disappear to a large extent. In some sections of the country, even where manures are at present necessary, little or no care is taken of the barnyard manure. A large proportion of the fertilising and humus-forming ingredients is lost, either through leaching, surface-washing, or fermentation and decay. The farmer who permits this waste, whether through ignorance or carelessness, is sure to feel the loss either in diminished crops or in increased bills for fertilisers. The barnyard manure should be as scrupulously cared for as any other farm product. It has been repeatedly shown in experiments in the East in growing stock for beef, mutton and pork, that a very large proportion of the profit was in the manure. If the value of the manure was left out of the account there was little or no profit from the operation. If the manure was valued at current rates for fertilising materials a fair profit was apparent.

ADVANTAGES OF SOILING.

The advantages of soiling, or feeding animals largely or wholly on green forage crops in the barn instead of pasturing them, are that less land is required to maintain a given number of animals, the food supply can be better regulated, the animals do not waste their energy in searching for food, and the manure can all be saved and applied to the soil. The arguments for partial soiling are that the amount of feed furnished by pastures is very irregular, being usually abundant and of good quality early in the season, but falling off later from droughts or early frosts In the case of milch cows unless some supplementary food is given at such times the milk flow diminishes and the cows fall off in flesh.

Concerning the relative amounts of food furnished by pasturing and by soiling, the Pennsylvania Experiment Station found in experiments in two years that "in round numbers we can produce from three to five times as much digestible food per acre by means of the soiling crops (rye and corn or clover and corn) as is produced by pasturage such as is represented by our small plat." The plat in question was believed to fairly represent the average pasture. From feeding trials with the above soiling crops and pasture grass the average yield of milk per acre was calculated as follows:

Yield of milk per acre of land.

	1888.	1889.
	Pounds.	Pounds.
Soiling	3,416	5,671
Pasturage	928	1,504
Difference	2,488	4,167

It will be understood that the above is partly an estimate, but it points very strongly in favor of soiling.

Trials at the station in Wisconsin showed that "by soiling in summer a certain area of land will yield double the amount of milk and butter that it will when pastured."

The Connecticut Storrs Experiment Station maintained 4 cows from June 1 to November 1 on a little less than $2\frac{1}{2}$ acres of soiling crops with the addition of a very light grain and straw feed.

At the Ontario Agricultural College and Experimental Farm about three fourths of an acre of soiling crops (green clover, green peas, tares, oats, and corn fodder) was sufficient, with the addition of 252 pounds of wheat bran, for 2 cows for sixty-three days. "We might expect, therefore, to grow on about 1 acre sufficient green food to feed a cow for two hundred days under ordinary conditions."

If soiling is to be practiced it is important to have a succession of green fodders throughout the growing season, with each in its best stage of growth for feeding. There should be no breaks in the succession and each crop should be used as nearly as possible at the time when it contains the largest amount of valuable food constituents.

From three years of experience and observation in the practice of soiling, the Connecticut Storrs Station suggests the following series of crops for soiling in Central Connecticut:

Crops for soiling in Central Connecticut.

Kind of fodder.		Amount of seed per acre.	Approximate time of seeding.	Approximate time of feeding.
1. Rye fodder	bushels	$2\frac{1}{2}$ to 3	Sept. 1 ...	May 10–20.
2. Wheat Fodder	do.	$2\frac{1}{2}$ to 3	Sept. 5 10 ...	May 20-June 5
3. Clover	pounds	20	July 20–30	June 5–15.
4. Grass (from grass lands)	...	...	...	June 15–25.
5. Oats and peas (each)	bushels	2	Apr. 10 ...	June 25-July 10
6. Oats and peas (each)	do.	2	Apr. 20 ...	July 10–20.
7. Oats and peas (each)	do.	2	Apr. 30 ...	July 20–Aug. 1
8. Hungarian grass	do.	$1\frac{1}{2}$	June 1 ...	Aug. 1–10.
9. Clover rowen (from 3)	...	...	...	Aug. 10–20.
10. Soja beans	bushels	1	May 25 ...	Aug. 20–Sep. 5
11. Cowpeas	do.	1	June 5–10 ..	Sept. 5–20.
12. Rowen grass (from grass lands)	...	...	...	Sept. 20–30.
13. Barley and peas each	bushels	2	Aug. 5–10 ..	Oct. 1–30.

The growing of a leguminous plant and a cereal together, as oats and peas, to be fed as green forage, has proved quite popular where it has been tried. The experiment stations in nearly every State have tested the adaptability of various fodder plants, leguminous and non-leguminous, and can furnish information as to selection, where seed can be obtained, etc.

By a judicious selection of soiling crops not only can a much larger number of cows be kept on a given area of land, but the land may be brought into a higher state of cultivation and fertility, and much grain may be spared.

Soiling is a feature of a more intensive system of farming, and finds more extensive application as the value of the land increases.

VALUE OF LEGUMINOUS CROPS FOR FEEDING.

Why should the farmer go on raising meadow hay as his main supply of coarse fodder and buying grain to supplement it, when by growing leguminous crops the nitrogen required by animals can be produced at the lowest cost? The crops of red clover, crimson clover, Japan clover (*Lespedeza*), cowpea, alfalfa, soja bean, horse bean, serradella, and many others of this class far surpass common hay in the food materials they contain, both pound for pound and in yield per acre. They may be grown as catch crops and used for soiling or pasturage, or they may be grown for making hay or silage. By mixing the green crops with corn and ensiling the two together a palatable and nutritious food is produced which is much richer in portein (nitrogen) than silage made from corn alone.

The cultivation of these leguminous plants involves somewhat more labour, as a rule, than raising grass hay, but it is believed that it will prove profitable for it enables the farmer to raise his own concentrated feed at the same time that he raises his coarse fodder. For instance, a recent experiment has indicated that soja-bean meal is fully equal to cotton-seed meal for milk and butter production. This meal is one of the richest feeding stuffs we have. It exceeds linseed meal and gluten meal in portein (nitrogen) and far exceeds these and cotton-seed meal in fat. It is only surpassed in protein by cotton-seed meal and some of the oil cakes little used in this country. The beans can be trashed out and ground and the straw fed as coarse fodder. This straw is richer in food materials than a good medow hay. It contains 9½ per cent. of protein while meadow hay averages about 7½ per cent. The cowpea may be treated in similar manner. The ground cowpeas are a richly nitrogenous feed, althouth not as rich as soja-bean meal; and the vines are nearly or quite equal to clover hay and far surpass grass hay in richness.

The following table shows the average composition of hay from leguminous crops as compared with hay from grasses:

Average composition of hay from grasses and leguminous crops

Hay from—	Water.	Protein.	Carbo-hydrates.	Fat.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Red top ...	8.9	7.9	76.0	1.9
Orchard grass ...	9.9	8.1	73.4	2.6
Timothy ...	13.2	5.9	74 0	2.5
Hungarian grass ...	7.7	7.5	76.7	2.1
Kentucky blue grass ...	15.0	8.2	78.1	4.4
Red clover ...	15.3	12.3	62.9	3.3
Crimson clover ...	13.4	14.0	55.6	4.1
Japan clover ...	10 9	13.8	63.1	3.7
Alsike clover ...	9 7	12 8	66.3	2.9
White clover ...	9.7	15.7	63.4	2.9
Alfalfa ...	8 4	14 3	67.7	2.2
Cowpea ...	10.7	16.6	62.3	2 9
Serradella ...	9.2	15.2	65.7	2.6
Vetch ...	8.4	14.5	67 8	2.1
Soja bean ...	6.3	14.5	66.6	5.6
Average for grasses ...	10.94	7 52	75.64	2.70
Average for leguminous plants ...	10.2	14.37	64.14	3.23

It may be said in general that 100 pounds of hay from leguminous crops contains about twice as much protein as 100 pounds of hay from grasses. The leguminous hay may be safely estimated as worth from one fourth to one third more for feeding than common hay. This is true in spite of the fact that it does not usually command a higher price in the markets, owing to certain prejudices against its use.

Assuming that the common grasses yield 2 tons of hay to the acre, and clovers, etc., 3 tons of hay, the amounts of food materials and fertilising materials in the crops are approximately as follows :

Relative yield of food and fertilising materials in crops of hay from grasses and from leguminous crops.

Hay from—	Assumed yield per acre.	Food materials in crop per acre.			Fertilising materials in crop per acre.		
		Protein.	Carbo-hydrates.	Fat.	Nitrogen.	Phosphoric acid.	Potash.
	Tons.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Red top ...	2	158	1,520	38	23.0	7.2	20.
Timothy ...	2	118	1,480	60	25.2	10 6	18.0
Red clover ...	3	369	1,887	99	62.1	11.4	66.0
Alfalfa ...	3	429	2,031	66	65.7	15.3	50.4
Cowpea ...	3	498	1,869	87	58.5	15.6	44.1
Soja bean ...	3	435	1,998	168	69.6	20.1	32.4

The amount of hay produced on different farms varies so widely that it is difficult to strike an average, especially for the leguminous crops. It will be seen that on the above basis, which is believed to be a fair one, the leguminous crops furnish from two to four times as much protein per acre as common grasses, together with much more fat and

rather more carbohydrates. They also contain nearly three times as much nitrogen and about twice as much potash. It should be remembered that under favourable conditions they may draw a large proportion of this nitrogen from the air, instead of depleting the soil, and that their long roots enable them to feed upon the potash deep down in the soil beyond the reach of surface-feeding plants.

Summary.

(1) Green manuring improves the physical properties of the soil by making the soil more porous and adding to its supply of humus. It brings up the dormant plant food from deep down in the soil and deposits it near the surface, where it can be used by plants feeding near the surface.

(2) Green manuring with buckwheat, Hungrian grass, and other non-leguminous plants adds practically nothing to the soil which was not there before, except a mass of vegetable matter which decays and goes to form humus.

(3) Green manuring with clovers, peas, beans, lupines, etc. (leguminous crops), actually enriches the soil in nitrogen drawn from the air. These plants can grow with very little soil nitrogen. They store up the nitrogen of the air as they grow, and when plowed under give it up to the soil and to future crops. It is the cheapest means of manuring the soil with witrogen.

(4) But animals, as well as plants, require nitrogen for food. By feeding the crops of clover, cowpea, etc., only about one fourth of the fertilizing materials of the crop is lost if the manure is properly cared for. As the nitrogen of the air is the cheapest source of nitrogen for plants, so it is the cheapest source of protein (nitrogen) for animals The leguminous crop is best utilised when it is fed out on the farm and the manure saved and applied to the soil. The greatest profit is thus secured and nearly the same fertility is maintained as in green mauuring.

(5) For renovating worn or barren soils, and for maintaining the fertility where the barnyard manure is not properly cared for, green manuring with such leguminous crops as cowpea, clovers, and lupines is recommended. A dressing of potash and phosphates will usually be sufficient for the green manuring crop.

(6) The practice of green manuring on medium and better classes of soils is irrational and wasteful. The farmer should mend his system so that the barnyard manure will be as well cared for as any other farm product. Loss from surface washing, leaching, fermentation, and decay should be guarded against. Then the feeding of richer food will mean richer manure and better and cheaper crops.

(7) The system of soiling, or feeding green crops in the barn in place of pasturage, enables a larger number of animals to be kept on a given area of land, and the manure to be more completely saved. For this purpose leguminous crops are extremely valuable.

(8) Hay from leguminous crops is about twice as rich in protein as hay from grasses. In the one case this protein (nitrogen) is obtained very largely from the atmosphere; in the other it is all drawn from the fertility of the soil. Leguminous crops yield larger crops of hay to the acre than grasses. Hence the production of food materials on an acre, especially protein, is several times larger with leguminous crops.

(9) If allowed to ripen, the seed of the cowpea and soja bean furnishes an extremely rich concentrated feed which can be ground and fed in place of expensive commercial feeds. The straw remaining may be fed as coarse fodder, for it is richer than ordinary hay.

(10) Grow more leguminous crops. They furnish the cheapest food for stock and the cheapest manure for the soil. They do this because they obtain from the air a substance necessary for plants and animals alike, which costs in the form of fertilisers and feeding stuffs from 15 to 25 cents a pound.

BARNYARD MANURE.

By W. H. Beal, of the Office of Experiment Stations, U. S. Department of Agriculture.

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MANURE AS A FARM RESOURCE.

The term "barnyard manure" is used to mean the solid and liquid excrement of farm animals either alone or mixed with litter and more or less fermented.

A well-kept manure heap may be safely taken as one of the surest indications of thrift and success in farming. Neglect of this resource causes losses, which, though vast in extent, are little appraciated. Waste of manure is either so common as to breed indifference or so silent and hidden as to escape notice.

According to recent statistics there are in the United States, in round numbers, 16,000,000 horses, 53,000,000 cattle, 45,200,000 hogs, and 45,000,000 sheep. Experiments indicate that if these animals were kept in stalls or pens throughout the year and the manure carefully saved the approximate value of the fertilising constituents of the manure produced by each horse annually would be $27, by each head of cattle $19, by each hog $12, and by each sheep $2. The fertilising value of the manure produced by the different classes of farm animals of the United States would, therefore, be for horses, $432,000,000; cattle, $1,007,000,000; hogs, $542,400,000; and sheep, $90,000,000, or a total of $2,071,400,000.

These estimates are based on the values usually assigned to phosphoric acid, potash, and nitrogen in commercial fertilisers, and are possibly somewhat too high from a practical standpoint. On the other hand, it must be borne in mind that no account is taken of the value of manure for improving the mechanical condition and drainage of soils, which, as the subsequent pages will show, is fully as important a consideration as its direct fertilising value.

Discussing this subject from a more practical standpoint, Prof. Roberts has suggested $250 as a conservative estimate of the value of the manure produced during seven winter months on a small farm carrying 4 horses, 20 cows, 50 sheep, and 10 pigs.

If we assume that one third of the value of manure is annually lost by present methods of management, and this estimate is undoubtedly a conservative one, the total loss from this source in the United States, as indicated by the first figures, would be about $690,466,000; or, using Robert's figures, the annual loss for each farm would amount to $83.33.

It should be clearly understood that when the farmer sells meat, milk, grain, hay, fruits, vegetables, etc., from his farm, or neglects to save and use the manure produced, he removes from his soil a certain amount of potash, phosphoric acid, and nitrogen that must be restored sooner or later if productiveness is to be maintained.

The following table compiled by Armsby shows the amount and value of fertilising constituents carried away from the soil in different products:

Manurial value of farm products.

	Pounds per ton.			Value per ton.				Manurial value of $10 worth.
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid	Potash.	Total.	
Meadow Hay	20.42	8.2	26.4	$3.47	$0.57	$1.06	$5.10	$5.10
Clover Hay	40.16	11.2	36 6	6.83	0.78	1.46	9.07	9.07
Potatoes	7 01	3.2	11.4	1.19	0.22	0.46	1.87	0 12
Wheat Bran	49.15	54.6	28.6	8.35	3.82	1.14	13.31	8.32
Linseed meal	105.12	32.2	24.8	17.87	2.25	0.99	21.11	7.54
Cotton seed meal	135.65	56.2	29.2	23.06	3 93	1.17	28 16	10.05
Wheat	37.53	15 8	10.6	6.38	1.11	0.42	7 91	2.63
Oats	36.42	12.4	8.8	6.21	0.87	0.35	7.43	3.86
Corn	33.66	11.8	7.4	5.62	0.83	0.30	6.75	3.78
Barley	39.65	15.4	9.0	6 74	1.08	0.36	8.18	3.03
Milk	10.20	3.4	3 0	1.73	0.24	0.12	2.09	0.88
Cheese	90 60	23.0	5.0	15.40	1.61	0.20	17.21	0.69
Live Cattle	53.20	37.2	3.4	9.04	2.60	0.14	11.78	1.18

We learn from the above table [says Armsby] that the farmer who sells a ton of hay, for example, sells in his ton of hay fertilising ingredients which, if purchased in the form of commercial fertilisers, would cost him about $5.10; that if he sells 2,000 pounds of wheat he sells an amount of nitrogen, phosphoric acid, and potash which it would cost him $7.91 to replace in his soil in the form of commercial fertilisers. Or, looking at it from a somewhat different standpoint, a farmer who sells, for example, $10 worth of wheat sells with it about $2 63 worth of the fertility of his soil. In other words, when he receives his $10 this amount does not represent the net receipts of the transaction, for he has parted with $2 63 worth of his capital, that is, of the stored up fertility of his soil, and if he does not take this into account he makes the same mistake a merchant would, should he estimate his profits by the amount of cash which he received and neglect to take account of stock.

If the farmer, instead of selling off his crops, feed them to live stock on the farm as far as possible, a large proportion of this fertility, as has been shown above, is retained on the farm; and "if the business of stock feeding is carried to the point where feed is purchased in addition to that grown on the farm, a considerable addition may in this way be made to the fertility of the farm at an almost nominal cost, since it is assumed that feed will not be bought unless its feeding value will at least pay its cost." This commendable system of indirect purchase of fertilisers in feeding stuffs is practised largely in England and other European countries, and accounts for no small share of the profits of stock-raising in those countries.

But it is evident that these advantages will not be secured unless the manure produced is carefully saved and used.

The growing of more leguminous plants, such as beans, peas, clover, lupines, etc., as a means of increasing the fertility of the soil, is strongly recommended both from theoretical and practical considerations, but as has been said:

> The leguminous crop is best utilised when it is fed out on the farm and the manure saved and applied to the soil. The greatest profit is thus secured and nearly the same fertility is maintained as in green manuring. * * * The farmer should mend his system so that the barnyard manure will be as well cared for as any other farm product. Loss from surface washing, leaching, fermentation, and decay should be guarded against. Then the feeding of richer food will mean richer manure and better and cheaper crops.

It is hard to persuade the farmer to abandon time-honoured practices and adopt methods with which he is unfamiliar. He also hesitates about incurring the necessary expense of building suitable receptacles for the storage of manure, frequently assuming that this is greater than it really is. As Roberts states "the new idea that the manure should be as carefully preserved from unnecessary waste as any other product of the farm is hard to put in practice, after having stored for forty years the farmyard manure under the eaves upon the steep hillside which forms one border of the running brook."

It is to be feared that the introduction of commercial fertilisers has not been without effect in increasing the apparent indifference with which this valuable farm resource is so often regarded. Too many farmers lose sight of the fact that, as a rule, commercial fertilisers should supplement and not entirely replace the manurial supplies of the farm.

AMOUNT, VALUE, AND COMPOSITION OF MANURE PRODUCED BY DIFFERENT ANIMALS.

It is of great importance to the farmer to know the amount and value of manure which will be produced in a given time by animals of different kinds, and various methods of calculating these approximately have been proposed. Some authorities base their calculations upon the amount of straw used as litter, assuming that for 1 ton of straw used as bedding, 4 tons of manure will be produced. Armsby shows, from carefully conducted experiments with horses, that where straw is used as economically as possible, each horse will require 2,500 pounds of straw per year for bedding purposes. Using this as a basis, he calculates "that a ton of wheat straw, economically handled, may result in 6 tons of fresh manure," but under ordinary circumstances it will probably not result in more than 5 tons. "In stables where but one or two horses are kept or where the manure is infrequently hauled away, the product might not greatly exceed 2½ tons when the time came to remove it."

Probably the most accurate method which has been used is that adopted by Heiden and others, which bases all calculations upon the amount of food consumed and litter used

The dried excrement of horses, cows and other neat cattle, and sheep is nearly one half of the dry food consumed. One hundred pounds of dry matter in food consumed by horses yields 210 pounds of manure, containing on an average 77.5 per cent of moisture. To this should be added the wegiht of bedding (amounting to about 6½ pounds per day) in order to get the total product of manure. Making allowances for dung and urine dropped outside of the stable, Heiden calculates that a well-fed working horse will produce 50 pounds of manure per day,

or 6½ tons per year, which can be saved. Boussingault's and Hofmeister's figures indicate this amount to be 5¼ to 5½ tons, while Armsby's put it at about 6¼ tons. Cows and other neat cattle produce manure containing on an average 87 5 per cent of water. One hundred pounds of dry matter consumed in food yields 384 pounds of manure, to which must be added the amount of litter used, which, according to Heiden, should be about one-third of the dry matter fed. Calculating on this basis, a steer weighing 1,000 pounds and consuming 27 pounds of dry matter per day would produce about 20 tons of manure per year.

Sheep excrete 49⅓ per cent of the dry matter of their food. The manure contains on an average 73 per cent of water. One hundred pounds of dry matter in the food would therefore produce 183 pounds of manure. A 60-pound sheep, fed 2 pounds of dry matter and receiveing three-fifths pound of bedding, would produce about 4.1 pounds of manure per day, or three-fourths ton yearly.

Careful observations have indicated that the pig produces from 12 to 16 pounds of manure per day, or from 2 to 3 tons per year.

The following table compiled from a bulletin of the New York Cornell Station shows the amount and value of manure produced by the principal kinds of farm animals fed liberally and given sufficient bedding to keep them clean, calculated to a uniform basis of 1,000 pounds live weight:

Amount and value of manure produced per 1,000 pounds of live weight of different animals.

	Amount per day.	Value per day.*	Value per year.*
	Pounds.	Cents.	
Sheep	34.1	7.2	$26.00
Calves	67.8	6 2	24.45
Pigs	83.6	16.7	60.88
Cows	74.1	8.0	29.27
Horses	48.8	7.6	27.74

The fertilising constituents and the value per ton of the manure obtained under the above conditions are shown in the following table in which is inserted for comparison the results of analyses by Storer of manure of hens, which is representative of that of fowls in general:

Analyses and value per ton of manure of different animals.

	Water.	Nitrogen.	Phosphoric acid.	Potash.	Value per ton.
	Per cent.	Per cent.	Per cent.	Per cent.	
Sheep ...	59.52	0.768	0.391	0.591	$3.30
Calves ...	77.73	0.497	0.172	0.532	2.18
Pigs ...	74.13	0.840	0.390	0.320	3.29
Cows ...	75.25	0.426	0.290	0.440	2.02
Horses ...	48.69	0.490	0.260	0.480	2.21
Hen manure ...	56.00	0.80 to 2	0.50 to 2	0.80 to .90	7.07

* Valuing nitrogen at 15 cents, phosphoric acid at 6 cents, and potash at 4½ cents per pound.

These figures probably fairly represent the actual fertilising value of the carefully preserved manure (both solid and liquid) of well fed and cared for animals. In all cases the manure was protected from leaching and in some cases treated with a small amount of gypsum as a preservative. "It will be noticed that the average amount of nitrogen recovered in all the manure is considerably more than that of the potash and about twice the amount of phosphoric acid."

In general practice the manure from the different kinds of animals is frequently collected in a common heap until needed. While it is difficult to state an average, mixed barnyard manure properly cared for may be safely assumed to vary in composition within the following limits:

			Per cent.
Nitrogen varies from	...	...	0.4 to 0.75
Phosphoric acid varies from	...	...	0.2 to 0.40
Potash varies from	...	...	0.4 to 0.75
Water varies from	...	...	70 to 80

COMPARATIVE VALUE OF SOLID AND LIQUID PARTS.

It is a fact often lost sight of in practice that the urine of animals is by far the most valuable part of the excreta. The solid excreta contains, principally, the fertilising constituents of the food which have failed to be digested or absorbed into the animal system and are, therefore, chiefly in insoluble forms. The urine, on the other hand, contains those fertilising constituents which have been digested and are largely soluble. The composition of the urine, like that of the solid excreta, varies with the kind and age of the animal, but especially with the nature of food, water drunk, etc., as will be explained later. The composition of the urine of different kinds of farm animals has been found by analysis to be as follows:

Chemical composition of the urine of different animals.

	Water.	Nitrogen.	Phosphoric Acid.	Alkalies.
	Per cent.	Per cent.	Per cent.	Per cent.
Sheep	86.5	1.4	0.050	2.0
Swine	97.5	0.3	0.125	0.2
Horses	89.0	1.2	...	1.5
Cows	92.0	0.8	...	1.4

The urine of farm animals may be said to be free from phosphoric acid except in case of sheep and swine, where it occurs in minute traces, but is rich in nitrogen and the alkalies (including potash and soda); consequently it is an incomplete manure and should be supplemented by phosphate if used alone. It is best, however, to apply it along with the solid excrement, which contains a considerable amount of phosphoric acid. This latter fact helps to explain why leachings from rotted manure are more valuable as a fertiliser than urine alone. The leachings contain in addition to the constituents of the urine the soluble constituents of the solid manure, among which is a considerable amount of phosphoric acid.

The comparative value of the solid and liquid excrement is shown in the following table:

Composition of solid and liquid excrement of farm animals.

	Water.		Nitrogen.		Phosphoric acid.		Alkalies (potash and soda).	
	Solid.	Liquid.	Solid.	Liquid.	Solid.	Liquid.	Solid.	Liquid.
	Per cent.	Per cent.	Per cent.	Per cent	Per cent.	Per cent.	Per cent.	Per cent.
Horses ...	76	89.0	0 50	1.20	0.35	Trace.	0.30	1.5
Cows ...	84	92.0	0.30	0.80	0.25	Trace.	0.10	1.4
Swine ...	80	97.5	0.60	0 30	0.45	0 125	0 50	0.2
Sheep ...	58	86.5	0.75	1.40	0.60	0 050	0.20	2 0

The urine is seen to be much richer than the solid dung in every case except that of pigs, in which the high percentage of water (97.5) causes the percentages of the other constituents to fall below those of the same constituents in the solid dung.

The fact that the urine of all farm animals (including pigs) is much richer than the solid excrement is strikingly brought out in the following table, which shows the composition of the dung and urine after the water has been completely removed.

Composition of dry matter of solid and liquid manure.

	Nitrogen.		Phosphoric acid.		Alkalies (potash and soda.)	
	Solid.	Liquid.	Solid.	Liquid.	Solid.	Liquid.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Horses ...	2.08	10.9	1.45	Trace.	1.25	13.6
Cows ...	1.87	10.0	1.56	Trace.	0.62	17.5
Swine ...	3.00	12 0	2.25	5.00	2.50	8.0
Sheep ...	1.78	10.4	1.42	0.37	0.71	14.9

The distribution of the manurial constituents in the urine and dung depends largely on the nature of the food. On this point Warington says:

If the food is nitrogenous and easily digested the nitrogen in the urine will greatly preponderate; if. on the other hand, the food is imperfectly digested the nitrogen in the solid excrement may form the larger quantity. When poor hay is given to horses the nitrogen in the solid excrement will exceed that contained in the urine. On the other hand corn, [oil] cake, and roots yield a large excess of nitrogen in the urine

Generally one half and frequently much more of the total nitrogen excreted will be found in the urine, a large portion of the potash, but little or no phosphoric acid or lime. In experiments with sheep at the Maine Experiment Station it was found that "the urine contained nearly half the potash of the total excreta and from half to three fourths of the nitrogen, but no phosphoric acid, the latter being wholly in the solid excrement."

The important points in this connection may be summarized as follows:

(1) Of the nitrogen, phosphoric acid, and potash supplied in the food, comparatively small amounts are assimilated and retained in the animal body, the relation between the amounts of these substances excreted in the urine and the solid excrement depending largely upon the nature of the food.

(2) The urine is much richer in nitrogen than the solid dung. It also contains considerable amounts of potash but is poor in phosphoric acid, which remains almost entirely in the solid excrement. The best results may therefore be expected from applying the mixed solid and liquid excrement.

The figures given in the preceding pages have only approximate and comparative value. They do not admit of too strict an application in practice, because barnyard manure, as can be readily understood, is a very variable substance. Its composition and value depend on a variety of conditions, the more important of which are (1) age and kind of animal, (2) quantity and quality of food (3) proportion and nature of litter, and (4) method of management of the manure and the length of time it is stored. Each of these factors will be discussed in detail.

INFLUENCE OF AGE AND KIND OF ANIMAL.

The proportions of the potash, phosphoric acid, and nitrogen of the food recovered in the manure vary considerably with the age and kind of animal. Full-grown animals, neither gaining nor losing weight, excrete practically all of the fertilising constituents consumed in the food. Growing animals and milch cows excrete from 50 to 75 per cent. of the fertilising constituents of the food; fattening or working animals from 90 to 95 per cent.

The variations in the composition of the manure of different classes of animals will be seen from the preceding tables. From these it appears that classified according to strength of equal weights of the normal manure produced the common farm animals stand in the following order: Poultry, sheep, pigs, horses, cows This difference in value, however, may be largely due to differences in the food commonly fed to the different classes of stock, as will be explained later.

Sheep manure contains a small amount of water and is, weight for weight, the richest manure produced by any of the common farm animals. It is what is called a hot manure, fermenting rapidly with the development of heat. Like horse manure it is especially liable to lose ammonia.

Horse manure is very dry and is therefore difficult to thoroughly mix with litter. It is a hot manure, undergoing fermentation rapidly and generating a high heat on account of its loose texture. It is likely to lose ammonia even more rapidly than sheep manure, and requires careful management—in use of litter, preservatives, etc.—from the moment it is voided. The composition of horse manure is more uniform than that of any other farm animal, chiefly because the food of horses is more uniform. The urine is especially rich.

Pig manure is very variable in composition, due to the variable nature of the food supplied to this animal, but is generally rich although containing a high percentage of water. It generates little heat in decomposing.

The manure of neat cattle, like that of pigs, and for the same reason, is variable in character, but is generally poorer than that of other farm animals on account of its large percentage of water. It decomposes slowly and develops little heat.

Poultry manure is very rich in all the fertilising elements, but especially so in nitrogen, due to the fact that the urinary secretions, which contain large amounts of nitrogen as well as potash in readily available form, are voided with the solid excrement. It quickly loses nitrogen, however, by fermentation if not properly mixed with absorbants or preservatives.

Warington states that for an equal amount of live weight the sheep produces on the same weight of dry food very much more manure than the pig, while the ox produces even more than the sheep.

It must be borne in mind, therefore, in estimating the manurial value of the dung of different animals that the quantity of dung voided by one animal is much greater than that voided by another. The amount voided by the cow, for example, is much greater than that voided by the horse, so that the inferior value of the former is to some extent compensated for by its greater quantity.

INFLUENCE OF QUALITY AND QUANTITY OF FOOD.

In a given class of animals the value of the manure is determined more by the nature of the food than by any other factor. The quantities of nitrogen, phosphoric acid, and potash in manure stand in direct relation to the quantities of the same ingredients in the food. The crop-producing power of the manure will be largely determined by the nature of the food supplied to the animals producing it. The following table, adapted from a bulletin of the New York Cornell Station, shows the wide variation in manurial value of some of the more common feeding stuffs. (See also table p. 171.)

Fertilising value of feeding stuffs.

—	Value of nitrogen in 1 ton.	Value of phosphoric acid in 1 ton.	Value of potash in 1 ton.	Total fertilising value per ton.
Cornmeal ...	$4.53	$0.83	$0.31	$5.66
Corn silage ...	0.78	0.14	0.32	1.24
Crimson clover (green) ...	1.29	0.16	0.44	1.89
Crimson clover hay ...	6.63	0.82	2.26	9.71
Red clover hay ...	5.70	0.54	1.31	7.55
Gluten meal ...	15.09	0.39	0.05	15.53
Cotton-seed meal ...	20.85	3.66	1.65	26.16
Linseed meal ...	16.08	2.28	0.99	19.36
Meat scrap ...	29.01	6.01	0.67	35.69
Wheat ...	7·08	0.96	0.45	8.49
Oats ...	5.36	0.90	0.45	6.70
Skim milk ...	1.74	0.26	1.08	2.11
Timothy Hay ..	3.00	0.43	1.17	4.60
Wheat bran ...	7.56	3 40	1.34	12.30
Wheat straw ...	0.81	0.30	1.02	2.18
Turnips ...	0.48	0.14	0.34	0.96

As already explained, from 50 to 95 per cent of the fertilising constituents of food is recovered in the manure, depending upon the kind of animal fed (see p. 176.)

In order to find from this table the amount of nitrogen, phosphoric acid, and potash which may be expected in manure, it is necessary simply to subtract from the amount of these constituents contained in the food the amount retained in the animal body. It can be readily seen that as regards the value of the manure produced the concentrated feeding stuffs, such as meat scrap, cotton-seed meal, linseed meal, and wheat bran stand first; the leguminous plants, such as red and crimson clover, etc., second; the cereals (wheat, oats, corn, etc.), third, and root crops last. Thus with full-grown animals neither gaining nor losing weight practically all of the fertilising constituents of the food are obtained in the manure and each ton of wheat bran, for example, fed would yield manure having a fertilising value of $12.30, each ton of clover hay $7.50, each ton of oats $6.70, and each ton of turnips 96 cents. With growing animals, milch cows. etc., only about 75 per cent of these amounts, or $9.20, $5.60, $5, and 72 cents, respectively, would be obtained in the manure. Finally, with working and fattening animals, which excrete about 90 per cent of the fertilising constituents of their food, the corresponding amounts would be $11, $6.75, $6, and 86 cents, respectively.

As the table shows, the amount of nitrogen present in foods is the most important element in determining the value of the manure, since it is the most costly fertilising constituent and is present in much larger proportion, as a rule, than phosphoric acid and potash. The inorganic substances of foods (potash, phosphoric acid, lime, etc.) pass very largely into the manure; consequently the manure is proportionately richer in these constituents than the food. The case is somewhat different with the nitrogenous substances, which are partly used in the production of meat, tendon, wool, milk, etc., thus leaving the manure in many cases poorer in nitrogen than the food consumed. Those, however, which are not so used undergo modifications in the process of digestion which render their nitrogen more available to plants.

As the New York Cornell Station has shown, increasing the amount of nitrogenous matter in the food increases the secretion of urine, thus necessitating the use of more litter and by this means increasing the bulk of the manure produced. The use of nitrogenous foods thus brings about the same result as the use of watery foods.

INFLUENCE OF THE NATURE AND PROPORTION OF LITTER.

Litter is used to furnish a clean and healthful bed for animals, to absorb and retain liquid excrement, to extend manure and render it easier to handle, to increase the physical and in some cases the chemical action of manure, and to check and control decomposition. The materials generally used are not, as a rule, rich in fertilising constituents, as the following table of composition given by Warington will show:

Fertilising constituents in one ton of litter.

	Nitrogen.	Phosphoric acid.	Potash.
	Pounds.	*Pounds.*	*Pounds.*
Dead leaves	16	6	6
Straw	8 to 12	4 to 6	12 to 32
Peat moss	16	Trace.	Trace.
Sawdust	4 to 14	6	14
Spent tan	10 to 20	...	...
Peat	20 to 40	...	...

The use of litter therefore tends to dilute manure rather than improve its chemical composition, but it absorbs and hold the valuable liquid parts and reduces the loss of ammonia.

MANAGEMENT OF MANURE.

We have seen that barnyard manure is a material which rapidly undergoes change. Where it is practical to haul the manure from the stalls and pen and spread it on the field at frequent intervals the losses of valuable constituents need not be very great, but when (as in winter) the manure must be stored for some time the difficulties of preservation become greatly increased.

Under these conditions, deterioration of manure results from two chief causes, (1) Fermentation, whereby a certain amount of the nitrogen is lost, and (2) weathering or leaching, which involves a loss of the soluble fertilising constituents, including potash and phosphoric acid as well as nitrogen.

Fermentation of Manure.

The fermentation of manure is due to the action of minute microscopic organisms which belong to two great classes, (1) those which require an abundant supply of air (oxygen) and which die when deprived of oxygen—known as aërobic ferments; (2) those which grow without oxygen and die when exposed to it—known as anaërobic ferments.

The decomposition observed in the manure heap is due as a rule to the combined action of these two classes of ferments. On the outer surface of the heap, where the air circulates freely, the first class (aërobic) is active, while in the interior of the heap, where the supply of air is limited, the fermentation is due to the anaërobic ferments. The latter soon run their course and cease to exist. Their functions seems to be principally to break up the more complex substances of the manure and prepare them for the further action of the aërobic ferments which finally convert them into simpler compounds such as water, carbonic-acid gas, and marsh gas.

Where the manure is compacted (as in deep stalls for instance) the carbonic acid gas formed by fermentation soon permeates the mass so completely as to entirely exclude the air, thus arresting fermentation. In loose heaps into which air is freely admitted fermentation of the aërobic form may go on indefinitely.

The fermentations of manure are very complex and vary according to circumstances. The principal conditions affecting these processes are (1) temperature, (2) supply of air as determined by compactness of heap, (3) moisture, (4) the composition of the manure, and (5) the nature of preservatives added.

The higher the temperature the more rapidly will manure decay. In aërobic fermentation of manure the temperature may rise to 122° to 140° or even 158° F. On the other hand, in the interior of the heap, where anaërobic fermentation is in progress, the temperature rarely rises above 95° F. Experiments have indicated that 131° F. is the most favourable temperature for manure fermentations.

As already explained, the supply of air determines whether the slow-acting anaërobic ferment or the more vigorous aërobic ferment predominates. The careful regulation of the two kinds of fermentation is necessary to the successful rotting of manure. If the heap is too loosely built the decomposition is too rapid. The materials useful for the formation of humus in the soil are destroyed, and the nitrogen, especially that of the urine, escapes into the air, largely in the form of ammonia. On the other hand, if the manure is too firmly packed the decomposition may be too slow and the manure will not become sufficiently disintegrated to produce the best effect in the soil.

A powerful means of controlling fermentation is the supply of moisture. The addition of water lowers the temperature and thus retards fermentation. By filling up the pores of the mass and excluding the air it checks aërobic fermentation when this becomes too active. French authorities maintain that the principal precautions necessary to prevent losses of ammonia consist simply in regularly and properly watering the manure with the leachings. In case of drought, if the leachings are insufficient, the lack should be made up with water.

The need of keeping manure moist is especially marked in case of horse manure, which is naturally dry and decomposes with great rapidity. The same is true in a less degree of sheep manure. The common and harmful "fire-fanging" is the result of an insufficient supply of water and may be readily checked by sprinkling. The sprinkling, however, should be regularly done and the heap kept in a constant state of moisture, otherwise the alternate wetting and drying will result in a loss of ammonia. Preservation of manure in this manner is generally practised in Europe and the product obtained is highly esteemed as a fertiliser. It is, "very dark coloured, or even black, and acquires a highly offensive odour, while the straw in it loses its consistency and become soft and incoherent." This black substance is held by certain French agriculturists to possess special value as a plant food. A method employed in the preparation of this well-rotted manure in France is as follows: The manure is placed on slightly inclined plats of packed earth or cement, so arranged that the leachings drain out into a pit from which they are pumped up and distributed over the manure heap. It is usual to provide two manure plats so arranged that when one is full (when the manure is 8 to 10 feet high) it may be allowed to ferment undisturbed while the other is used. The manure is carried from the stables to the top of the manure heap in wheelbarrows over an inclined plane of boards. Care is also taken to smooth down the sides of the heap to prevent the too free access of air

and the loss of leachings. The system here described is illustrated in fig. 1.

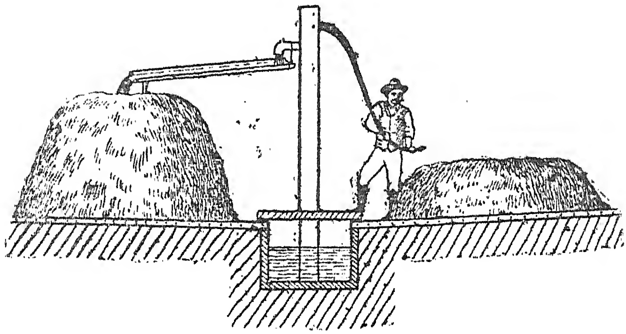

Fig. 1.

The French method of keeping manure.

It has been questioned whether the construction of expensive cisterns for collecting the manure leachings repays the cost, but it is obviously desirable from what has been said regarding the value of the liquid manure and the desirability of promoting regular and uniform fermentation of the manure, that the leachings should be saved and added to the manure heap by some means. Stored separately, the liquid part rapidly deteriorates and the solid part, from lack of moisture, is liable to undergo "fire-fanging," or harmful fermentation.

The nature and extent of fermentation in manure also depends to some extent on the composition of the manure, more particularly upon the amount of nitrogen in a soluble form which it contains. The greater the amount of soluble nitrogen the more rapid the fermentation. Urine, as we have already seen, is rich in soluble nitrogenous compounds, and this explains why it decomposes so rapidly.

By fermentation manure decreases rapidly in bulk. The substance of which it is composed are converted largely into water and gases, principally carbonic acid gas, and where fermentation is not properly controlled, nitrogen may escape either in the free gaseous state or as ammonia. The coarse materials of the manure are gradually decomposed and are dissolved to a considerable extent in the black liquid which oozes out of the manure heap. The mineral matter (the phosphates, potash, etc.) is also rendered more soluble. When properly controlled, therefere, fermentation is a valuable means of increasing the availability of the fertilising constituents of manure, although it decreases the bulk; but when not properly controlled it seriously reduces the value of the manure.

Leaching of Manure.

Leaching is the second cause of deterioration of manure. When manure is exposed to the action of the elements and the leachings allowed to drain away it rapidly decreases in value. Both the organic and the mineral constituents originally present or which have been made soluble by fermentation are carried off and lost. Experiments at the New York Cornell Experiment Station indicated "that horse manure thrown in a loose pile and subjected to the action of the ele-

ments will lose nearly one half of its valuable fertilising constituents in the course of six months; and that mixed horse and cow manure in a compact mass and so placed that all water falling upon it quickly runs through and off is subjected to a considerable, though not so great, a loss."

The Kansas Station concludes from similar observations "that farm-yard manure must be hauled to the field in spring, otherwise the loss of manure is sure to be very great, the waste in six months amounting to fully one half of the gross manure and nearly 40 per cent of the nitrogen that it contained."

The following experiments made by Dr. Voelcker in England show very strikingly the loss in weight and of nitrogen in manure stored under different conditions. Mixed manure containing 66.2 per cent of moisture was divided into three 1,000 pound lots. Lot 1 was placed in a heap in the open air, lot 2 in a heap under a shed, and lot 3 was exposed in the open air in a thin layer. The weights of the manure and the amounts of nitrogen it contained at the end of different periods were as follows:

Losses of Manure under different methods of Storing.

—	In heaps under a shed.		Exposed to air in heaps.		Exposed to the air in thin layers.	
	Weight.	Nitrogen.	Weight.	Nitrogen.	Weight.	Nitrogen.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
Manure at the beginning of experiment	1,000	6.43	1,000	6.43	1,000	6.43
Manure after 6 months	495	5.91	714	6.39	865	4.66
Manure after 9 months	398	5.02	703	4.19	612	2.47
Manure after 12 months	379	5.77	700	4.55	575	2.27
Moisture at end of 12 months (per cent.)	41.6		74.3		65.6	

The manure stored in a heap under cover lost 14 per cent of its nitrogen in twelve months; exposed in a heap, 30 per cent; and exposed in thin layers, 64 per cent.

Field experiments by Kinnaird with manure kept in an open court and under cover resulted in an increase of about 4 tons of potatoes and 10 bushels of wheat per acre in favour of the covered manure. The comparative value of leached and unleached manure has been carefully tested at the Ohio Station on corn and wheat and mixtures of clover and timothy. The experiments show a wide difference in value between the leached and unleached manure and indicate that the margin of profit from open-yard manure is extremely small.

Preservation of Manure.

Having now briefly discussed the nature and extent of the changes which manure is likely to undergo when stored in heaps, let us enquire into the best means of preventing loss of fertilising value during these changes. It is a well-known fact that certain of the organisms which cause decomposition of manure are voided with the dung and commence

their activity at once. In case of horses and sheep these organisms cause a considerable loss of ammonia in a comparatively short time. It is necessary therefore to adopt prompt measures in order to reduce loss from this source to a minimum. The means which are available for this purpose are the use of absorbents and preservatives, such as straw, peat, sawdust, dirt, gypsum (land plaster), kainit, etc. The litter takes up the liquid manure, thus preserving it to some extent from decomposition and also absorbs to a considerable extent the ammonia produced by fermentation and prevents its escape into the air.

The relative absorptive power of various materials commonly used as absorbents in stables is shown in the following table:

Absorptive power of different kinds of litter.

—	Water retained by 100 lbs. of materials after 24 hours.	Ammonia absorbed by 100 lbs of dry matter in different materials.
	Pounds.	Pounds.
Wheat straw	220	0.170
Partially decomposed oak leaves	162	—
Peat	600	1.103
Sawdust	435	0.046
Spent tan	450	—
Air dried humus soil	50	0.660
Peat moss	1,300	0.863

It thus appears from the table that peat and peat moss are the best absorbents. It has already been shown (p. 178) that they also furnish the largest amounts of fertilising constituents. Peaty soil is also an effective absorbent, and the use of a mixture of peaty earth with straw as litter as been strongly recommended. An addition of from 35 to 40 pounds of loam per head daily has been found advantageous, and where straw is scarce it has been replaced to the extent of one fourth or one third by earth. The amount of litter required for any given animal depends largely upon the character of the food. Watery foods and those containing a large amount of nitrogen increase the secretion of urine and so increase the amount of litter necessary to absorb the liquid and keep the animal clean. A safe general rule is that the litter should amount to at least one third of the dry matter of the food consumed. The following amounts per day for different animals are recommended: Sheep, three fifths pounds of litter; cattle 9 pounds; and horses, 6½ pounds.

It is not advisable as a rule to use an excess of litter beyond that required to keep the animal clean and absorb the liquid excrement, since the materials available for bedding are as a rule poor in fertilising constituents, and so extend and dilute the manure unnecessarily.

A small amount of gypsum (land plaster) sprinkled on the moist dung or urine is a popular and effective means of fixing the ammonia. It should be remembered, however, that unless the gypsum becomes moist it will have little effect. Kainit used in the same way tends to arrest fermentation, but it must be used with caution or it may injure the feet of the animals standing on it. Both kainit and acid phosphate sprinkled on the manure before it is thrown into the heap are val-

uable as preservatives, and besides increase the value of the manure, increasing the proportion of those constituents (potash and especially phosphoric acid) in which it is somewhat deficient. German investigators who have given a great deal of attention to the subject of preservatives for manure unanimously recommended the use of superphosphate-gypsum, a by-product of the manufacture of superphosphates; but as this product is not found in the American market its place may be taken by the ordinary acid phosphate or superphosphate of the trade used in connection with a small amount of gypsum.

A German authority recommends the use of approximately the following amounts of the different preservatives per day:

Amounts of different preservatives to be used per head daily.

—	Per horse 1,000 pounds weight.		Per cow, 880 pounds weight.		Per pig, 220 pounds weight.	Per sheep, 110 pounds weight.
	Lbs.	Oz.	Lbs.	Oz.	Ounces.	Ounces.
Superphosphate ...	1	0	1	2	3	$2\frac{1}{2}$
Gypsum ...	1	9	1	12	$4\frac{3}{8}$	$3\frac{3}{8}$
Kainit ...	1	2	1	5	4	$3\frac{1}{8}$

If both superphosphate and gypsum are used, the above proportions of these materials should be reduced from one third to one half. Kainit should be applied to the fresh manure and covered with litter so that it does not come in contact with the feet of the animals. Whether it will be good economy to use these materials for this purpose will depend upon their market price in the locality in which it is proposed to employ them.

In cases where different kinds of animals are kept, one of the most effective means of securing moderate and uniform fermentation of the manure heap is to see that the moist "cold" cow and pig manure is intimately mixed with the dry "hot" horse and sheep dung. The former makes the heap more moist and checks the too rapid fermentation and "fire fanging" of the latter.

It will be understood from what has been said that in order to reduce the loss to a minimum, manure heaps should be made compact and kept moist. Under cover the last result is secured by collecting the liquid manure and at frequent intervals sprinkling it over the heap, or when the supply of this is deficient, by sprinkling with water. Where the manure heap is exposed to the rain in pits from which there is no drainage it probably does not require so much attention, but still care must be taken to prevent loss by alternate leaching when heavy rainfalls occur, and drying out in time of drought.

Regarding the management of manure, Prof. Frear, of the Pennsylvania Experiment Station, says:

To secure such kind and degree of rotting as shall make the manure easily handled and put it into the condition best suited to the crops it is to fertilise, both extremes of moistness and cold, and of exposure and heat, are to be avoided.

It is a much-discussed question whether this mean condition is best obtained in practice by the preservation of the manure in dished yards, subject to more or less exposure to wind and sun, to full exposure to rain, but to more loosely leaching,

or under covered sheds where it is protected from sun and rain, and largely from wind. In both cases it is supposed to be compacted fully as the heaps are forming.

Storer expresses a doubt whether sheds built to shelter manure have ever paid their cost. On the other hand, Prof. Roberts of the New York Cornell Station, recommends the construction of sheds or covered yards for the protection of the manure. The use of completely covered barnyards for protecting manure has in recent years met with much favour in certain parts of the country. The manure from the horse and cattle stables and the sheep and calf pens is spread out evenly over these yards, covered with coarse litter, and the whole kept firmly packed by allowing animals to run over it, thus preventing injurious fermentation. The construction of a cheap and durable covered yard, illustrated in fig. 2 is thus described by Roberts:

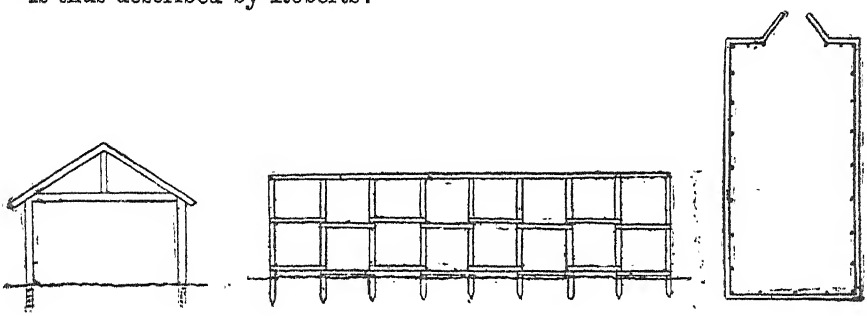

Fig. 2.

Plans for a cheap covered barnyard.

Long posts or poles, 8 inches in diameter at the butt, are set in the ground 2 feet deep and 6 feet apart. Upon these are spiked 2 by 4 scantling, about 4 feet apart for nailing girts, and a plate 2 by 6 is nailed on top of the posts which have been previously sawed off to a line after the girts have been spiked to them. Round poles flattened at the ends, or 2 by 6 joists doubled, spiked to the heads of the posts, will tie the building together. Ten feet will be quite high enough for the story; and one story will suffice if no straw is to be stored above except that which is placed there to exclude the cold. A few poles or old rails laid on these cross-ties which bind the building together will suffice to sustain the weight of the straw, while the straw will exclude the cold, and absorb the moisture far better than an expensive matched ceiling.

On the inside of the posts which have been set in the ground flattened poles, rails or slabs, or cheap boards may be nailed horizontally, and the space between the outside vertical boarding and the inside horizontal boarding may be filled with straw. This kind of a wall is far drier and more comfortable for the animals than one made of costly stone or brick.

If it is desired to have a place to store straw, the building should be higher, the joists stronger and more numerous than in the one-story building, and they will all have to be supported by a timber, supported by posts placed under their centres. The roofs should be steep, and can be made of any materials which will shed water. When the posts which have been set in the ground have rotted off, or are much decayed, they may be sawed off even with the ground and supported by placing underneath each one of them a large flat stone. Whenever the building is treated in that way it will be necessary to brace it thoroughly. It might be well in a windy country to brace so wide a building at the start.

Such a building will be inexpensive and reasonably durable. It will serve as a place for depositing manure when needed; it will shelter the animals while they are being watered and the stables are being cleaned and aired, and give facilities for preventing loss of valuable fertilising material either by leaching or firing.

A more elaborate and expensive style of covered yard, suggested by the American Agriculturist, is shown in fig. 3, which is worth considering when the construction of a barn is contemplated.

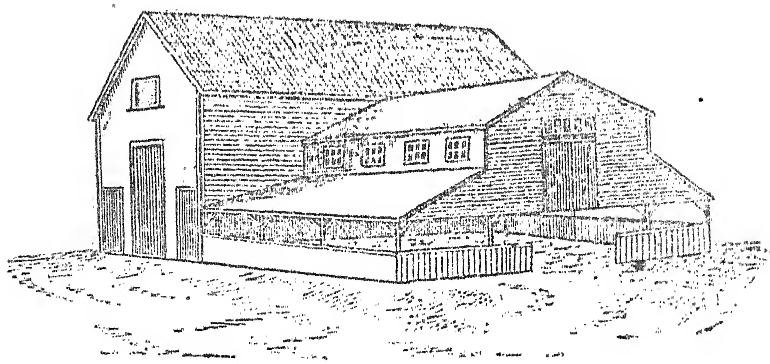

FIG 3.

A convenient covered barnyard.

This provides not only for the required protection of both animals and manure but affords also an excellent grain chamber where grain can be stored for convenient use. Under the side roof is also afforded a chance for the storing of small tools and a great variety of articles that are continually in the way when stored about the farm buildings. It also provides splendid protection to animals when housed at night during the summer, this roof protecting them from heavy showers in the night and affording an excellent opportunity for exercise in the winter, as all the sides, except that toward the south, can be protected against cold winds by being temporarily boarded up.

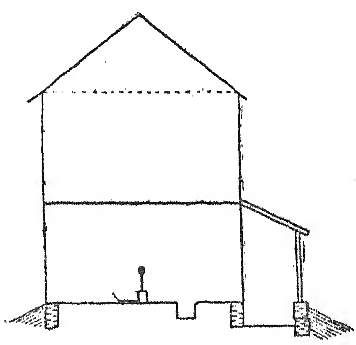

FIG. 4.

A cheap shelter for manure.

Many stables are so situated that by adding a cheap lean to, as shown in fig. 4, "a receptacle for caring for the manure is easily provided. The outside boarding of the lean to should be, for a part of the way at least, put on horizontally and hung in the form of flat doors, so that the manure can be easily loaded on a waggon standing on the outside of the building."

The unsatisfactory results attending the use of manure sheds and covered yards have probably been due to the fact that these structures

have generally been loosely constructed, allowing the free circulation of air which has dried out the manure. We have already seen the losses caused by dry fermentation. On this account barn cellars, so common in New England, possess decided advantages as receptacles for manure. The common practice of allowing swine to "work over" the manure in these cellars is a wise one, since it mixes the manure and keeps it well packed and moist. In fact, if these cellars are provided with impervious bottoms to hold the liquid manure, this system of storing manure is probably the most perfect practised.

In the method practised in France, the manure heap is under cover and well compacted. Loam, peaty earth, or similar materials are added to moderate fermentation. The impervious floors on which the heap is placed, as explained on page 180, are so arranged that the leachings may be collected and returned to the heap, thus keeping it moderately moist. To prevent mixing fresh manure with old, two floors are provided, so that the manure on one may ferment undisturbed while the other is used.

The method in which the manure is carried regularly from the stable and placed in shallow pits with impervious bottoms, where it is closely packed by allowing animals to run over it, is practised to a considerable extent both in this country and in Europe, and, as recent experiments at the Pennsylvania Station indicate, it is probably as safe a method as storing in an open shed where no special precautions are taken to keep the manure moist throughout. The objections to it are that the manure is subjected to extremes of drought and moisture and must suffer injury in consequence unless special precautions are taken to guard against these extremes.

A third method, which originated in Europe and is practiced to some extent in this country, is that in which the soil in the stable is removed to a level below that of the outside and the bottoms tamped or cemented. The manure is allowed to accumulate under the animals until it is hauled to the fields, bedding being used in abundance. The feeding troughs are made adjustable so that they can be raised or lowered as required. The manure becomes highly compacted and is kept in a favourable condition of moisture, so that fermentation proceeds slowly and uniformly. At the same time the manure is completely protected from the action of the weather. As would naturally be expected under the circumstances, the manure obtained is stronger than that allowed to ferment in heaps in the ordinary way. This method is highly regarded where it is practised and it is claimed that the health of the animals does not suffer.

It is hard to understand, however [says Storer], how the hoofs of the animals can always escape the diseases that are apt to be caused by certain minute organisms which appear to harbour in fermenting dung, and no man can tell without trial how well the system would answer for dairy farms in this country, i. e., in the warmer parts of it. Doubtless it would serve well enough, however, in the case of fattening cattle.

Whatever the system adopted, the following general rules should be observed in the storage of manure: (1) Spread the manure out uniformly; (2) guard as much as possible against the access of air; (3) keep the manure always moist, but not too wet; (4) protect the heap from sunshine.

USE OF MANURE.

It is the prevailing opinion of chemists as well as practical men that where it is practicable it is best to apply manure and urine to the soil in the freshest possible condition. The fertilising constituents of well-rotted manure, as already explained, are more quickly available to plants; the manure itself is less bulky, easier to distribute, and affords a good breeding place for organisms which promote nitrification* in the soil; and is less likely to promote rank growth than fresh manure. On the other hand, fresh manure mixed with the soil readily undergoes a fermentation which not only increases the availability of its own fertilising constituents, but also assists in rendering soluble the hitherto insoluble fertilising constituents of the soil. In fact, even with special precautions to prevent injurious fermentation under the feet of the animals and in the heap, the greatest return is likely to be gotten from manure applied in the fresh condition.

The form in which manure should be applied (whether fresh or rotted) is determined largely by the soil on which it is to be used. If improvement of the mechanical condition is the main object sought, the best results will be obtained by applying the fresh manure to the heavy clay soils, and the well-rotted manure to the light soils. If, however, the prompt action of the fertilising constituents of the manure is desired, light soils, in a favourable season, are likely to utilise coarse manure to better advantage than heavy soils. Decomposition takes place slowly in heavy soils and the constituents of the fresh manure become available very slowly. In light soils, on the other hand, unless the season is dry, the conditions are such that the manure decomposes readily, and the fertilising constituents are probably rendered available as fast as the plant needs them. There is also considerable danger on this class of soils that some of the soluble constituents will be carried away in the drainage if well-rotted manure is applied. For this reason such manure should be applied to light soils shortly before it is likely to be needed by the crop. Small applications at frequent intervals is a safe rule to follow on these soils. In general, it may be said that for spring application the more readily available rotted manure is preferable to the fresh unrotted material.

On clay soils it often happens that manure produces no effect whatever during the first year on account of slowness of decomposition, but since the clay possesses very powerful absorptive properties the manure is not lost. The fertilising constituents are retained in the soil and are finally utilised by the crop. There is therefore no danger in applying to clay soils large quantities of manure a long while in advance of the planting of the crop. During dry seasons the manure may produce little effect, but with a sufficient amount of moisture its action is likely to be considerable. The application to such soils of large quantities of manure improves their physical condition, and by the addition of humus renders more porous those which are too compact.

The behavior of calcareous soils toward manure is very variable, depending upon the compactness of the soil. In those which are suffi-

*Nitrification is the process by which the highly available nitrates are formed from the less active nitrogen of organic matter, ammonia salts, etc. It is due to the action of minute microscopic organisms which develop only in the presence of air, moisture, and a basic substance such as lime or an alkaline carbonate.

ciently porous decomposition goes on with great rapidity, and the soluble fertilising constituents formed are partially carried away in the drainage water before they can be taken up by the plants. For this reason, as in case of light soils, the manure should be applied in small amounts and at frequent intervals.

The climate also may have an important bearing on this subject. In a warm, damp climate it is a matter of comparative indifference whether the manure is fresh or well rotted when it is applied, since under this conditions decomposition in the soil will be sufficiently rapid. In a dry, hot season, however, it is well known that excessive applications of undecomposed manure manifest a tendency to "burn out" the soil and this tendency, as has just been stated, is more marked in light soils than in heavy. In cold climates, where the season is short and the conditions for rapid fermentation in the soil unfavourable, the use of fermented manure is preferable.

Fresh manure has a forcing effect and tends to produce stems and leaves at the expense of fruit and grain. It is therefore better for grasses and forage plants than for cereals.

Direct application of manure, as is well known, seriously injures the quality of tobacco, sugar beets, and potatoes, although mangel-wurzels appear to profit by large applications. For these reasons it is advisable in the case of cereals, tobacco, potatoes, and sugar beets to apply the manure to the previous crop, or, where land is to be planted in the spring, to apply in the fall and allow to decompose during the winter. Sir J. B. Lawes has pointed out, however, that wheat on light soil is benefited by direct applications of manure, and that it is only on heavy soils that it is best to apply it to the preceding crop.

"Manifestly," as Storer remarks, "the rankness of fresh dung and urine could be controlled and utilised by applying the manure in small quantities and supplementing it with artificial fertilisers of kinds appropriate to the crops that are to be grown."

What has been said above regarding the application of fresh manure applies especially to manure containing only small amounts of coarse undecomposed litter. It is not generally advisable to apply very coarse manure before the litter has become at least partially decomposed.

It appears, therefore, that no fixed rules regarding the condition in which manure should be used which will apply to all cases can be laid down. It is a matter which naturally must be left largely to the individual judgment of the farmer, based upon a careful study of the character of the soil and climate and the requirements of the crop to be grown.

Methods of applying Manure.

In applying manure to the field three methods are pursued: (1) The manure is placed in larger or smaller heaps over the field and allowed to remain some time before being spread; (2) it is broadcasted and allowed to lie on the surface for some time, or ploughed in immediately, and (3) it is applied in the hill or drill with the seed.

The first method is objectionable because it increases labour of handling and chances of loss by fermentation and leaching, while uniform distribution of the manure is not likely to be secured. The spots on which the heaps stand are strongly manured with the leachings of the

manure, while the rest of the field receives the coarse parts of the manure largely deprived of its valuable constituents. Another disadvantage of this method is that proper fermentation is interfered with by the leaching out of the nitrogenous matter and the drying action of the wind. The practice of storing manure in large heaps in the field is subject to some extent to the same objections. If, however, the heap is not allowed to lie too long and is carefully covered with earth the loss may be greatly reduced.

Spreading the manure and allowing it to lie on the surface should be practised only on level fields where there is no danger from surface washing. It has been claimed that when manure is spread broadcast and allowed to lie on the surface there may be a serious loss of ammonia into the air, but experiments have shown that, in case of properly prepared manure, loss from this case must be very small. On a leachy soil there may be a loss of soluble constituents in the drainage if the manure is spread a long while before the crop is planted, but in ordinary practice the loss from this source is also likely to be insignificant. In this method of application the fertilising constituents of the manure are uniformly distributed, the liquid portion being gradually and thoroughly incorporated with the soil particles. One serious disadvantage, however, of the method is that the manure before being ploughed in is leached to a large extent of its soluble nitrogenous compounds, which as we have already observed, are necessary for fermentation; and that for this reason it does not so readily ferment in the soil. It is highly advisable, therefore, in the case of light or sandy soils, not to follow this practice, but to plough the manure in as soon as spread.

As to the depth to which it is advisable to plough the manure in, the general rule should be observed that it should not be so deep as to prevent the access of sufficient moisture and air to insure fermentation and nitrification and to permit of rapid washing down of nitrates to the drain. In very compact soils the depth should not exceed 4 inches. In light soils this depth may be considerably increased, although in such soils there is more danger of loss by drainage than with heavy clay soils.

Application in the hill or drill is useful where the supply of manure is limited and the full immediate effect is desired. For forcing truck crops this method is especially valuable. Well-rotted manure is best suited to this method of application. It has been claimed, however, that manure applied in this way sometimes injures the appearance of root crops, especially potatoes, by increasing the amount of scab.

The so-called parking system, or feeding animals on the land, is a method of application which has many advantages; but the distribution of the manure by this system is irregular, and if practised in autumn or winter the manure is subject to loss by drainage.

The application of liquid manure has certain obvious advantages, and is largely practised, especially in Europe. Manure leachings is a quick-acting, forcing manure, and is especially valuable for grass. The expense of cisterns for collecting the leachings and the trouble of hauling and distributing, together with the care which must be exercised to prevent loss of nitrogen from the readily fermentable liquid when it stands for any length of time, render it doubtful whether this method is practicable except for special purposes and under peculiar conditions.

Rate of Application.

As to the rate at which manure should be applied no fixed rules can be given. The rate will depend upon the character of the soil, the quality of the manure, the nature of the crop, and the frequency of application. Cold moist soils should be manured lightly and often. Thaer, a German writer, states 17 to 18 tons per acre to be an abundant application, 14 tons good, and 8 to 9 light; other German writers consider 7 to 10 tons light, 12 to 18 tons usual, 20 tons or more heavy, and 30 tons very heavy. Stephens suggests 8 to 12 tons for roots and 15 to 20 tons supplemented by commercial fertilisers for potatoes. Sir Henry Gilbert considers 14 tons per acre annually excessive for wheat and barley. In New England the rate varies from 6 to 12 tons. Twenty tons is a frequent application in New Jersey, as well as in other regions where truck farming is practised. As a general rule it is more scientific to apply small amounts of manure freguently than to apply large amounts at longer intervals.

COMBINING BARNYARD MANURE WITH OTHER FERTILISING MATERIALS.

It has been the general experience that probably the best way to utilise barnyard manure is in combination with such materials as supplement and conserve its fertilising constituents. It has already been pointed out how certain substances, such as kainit and superphosphate, which possess a high fertilising value, may also be used to advantage as preservatives on account of their ability to check fermentation or to fix ammonia. Even the limited extent to which it is necessary to use these materials in the stable will improve the fertilising value of the manure, but it is necessary to do more than this if a well-balanced fertiliser is desired, for, as has been shown, barnyard manure considered simply as a supplier of nitrogen, phosphoric acid, and potash is comparatively poor. It has been shown that the proportions of potash and phosphoric acid especially are low. The potash, however, is in a very available form and does not need to be reinforced to the same extent as the much less available phosphoric acid.

Although nitrogen is the constituent most abundant in manure it has been found that in order to get the best results in general it should be reinforced if prompt action is desired. This is explained by the fact that a large part of the nitrogen of manure is very slowly available. Sir Henry Gilbert says on this point:

> The nitrogen of farmyard manure must obviously exist in very different conditions. That due to the urine of animals will be most rapidly available, that in the finely divided matter in the feces will be much more slowly available, and that in the litter still more slowly available. Hence, the small proportion that is at once effective and the very large amount that accumulates within the soil in a very slowly available condition.

Experiments at Rothamsted indicate that the nitrogen of barnyard manure is not half as valuable, weight for weight, as that of sulphate of ammonia.

What has been said about supplementing barnyard manure with more concentrated fertilising materials should not be taken to imply that the two kinds of fertilisers should necessarily be composted or applied at the same time. It may be desirable to apply the manure at

intervals of several years, while the concentrated fertilisers would need to be applied annually. However this may be, the facts above given should be borne in mind in applying the supplementary fertilisers.

Whether the farmer can afford to incur the necessary labour and expense involved in the preparation of composts is a question on which there is considerable difference of opinion. This is a matter which must be determined largely by individual needs and conditions, but undoubtedly the manure heap may be utilised to advantage for such purposes as reducing bones and other waste products of the farm and for "killing" cotton seed before it is applied to the soil.

In preparing composts the following directions should be observed: Select a level spot under shelter and convenient to the stables. Remove the earth so as to give a gentle slope from the sides toward the centre. It is advisable to tamp the floor of this pit firmly or cover it with puddled clay to prevent loss of leachings. It is also well to have a small drain leading from the centre to the side and emptying into a half barrel sunk in the earth. By this means the valuable leachings may be collected and bailed out and sprinkled over the heap, thus assisting materially in promoting a moderate and uniform fermentation of the manure. It is not necessary, however, to provide for this collecting of the leachings if in the construction of the heap the precaution is taken to lay down first a fairly thick layer of the absorbent materials, such as barnyard manure, peat, etc., which it is intended to use. Put down first a layer of these materials, then follow with a layer of acid phosphate, for instance, and so on until all the materials are used, wetting each layer thoroughly first with water or urine if it is at hand, and finally with kainit, or other chemicals used dissolved in water. It is well to have at hand a mixture of peaty earth and plaster with which the finished heap is covered to a depth of about 1 inch. The heap should be examined from time to time and moistened with manure leachings, urine, or water if there appears to be any danger of overheating. In from four to six weeks the compost is ready to be forked over, thoroughly mixed, and carried to the field.

The following formulas for composts in which barnyard manure is one constituent have been recommended and in may cases have been tried with favourable results.

Formulas for cotton.

	No. 1.*	No. 2.	No. 3.	No. 4.	No. 5.†	No. 6.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
Stable manure ...	750	750	400	300	300	1,000
Cotton seed ...	750	750	600	600	600	1,000
Acid phosphate ...	333⅓	500	800	750	...	1,000
Floats ...	...	...	...	...	750	...
Kainit ...	166⅔	...	200	350	350	...
Rate per acre ...	1,600	1,600	1,600	1,600	1,600	...

* Furman's formula.

† Found especially effective in experiments on cotton.

Formulas for cotton and corn.

	No. 7.*	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
Stable manure ...	800	500	600	600	...	600
Stable manure with yard scrapings	...	...	...	...	1,000	...
Cotton seed ...	750	...	400	...	...	...
Cotton-seed meal or fish scrap	...	...	...	700	...	...
Acid phosphate ..	...	...	800	600	...	...
Acid phosphate or bone meal	...	...	...	...	800	600
Dissolved bone ...	450	500	...	...	...	...
Sulphate of ammonia ...	...	150	...	...	...	...
Kainit ...	...	...	200	100	200	...
Sulphate of potash ...	...	1'0	...	...	...	...
Unburnt marl ...	...	500	...	...	...	...
Salt ...	...	200	...	...	...	...
Ashes ...	...	...	...	...	...	200
Rich earth or yard scrapings	...	...	...	...	...	600
Rate per acre ...	300–500	300–500	...	...	...	...

* When applied to corn on worn soil should be supplemented by 75 pounds of muriate of potash per acre; when used on wheat by 50 pounds of sulphate of potash and by 100 pounds of nitrate of soda sown broadcast in the spring.

Formulas for winter wheat, rye, corn, and cotton.

	No. 13.	No. 14.
	Pounds.	Pounds.
Barnyard manure	700	700
Cotton seed	800	...
Castor pomace	...	700
Dissolved boneblack	...	600
Dissolved bone meal	500	...
Rate per acre	500–800	500–800

Formulas for wheat, oats, or rye.

	No. 15.	No. 16.	No. 17.	No. 18.
	Pounds.	Pounds.	Pounds.	Pounds.
Stable manure	...	800	600	600
Stable manure or any rich earth or mould ...	600	...	...	...
Cotton seed	600	...	...	...
Cotton-seed meal	...	...	...	700
Kainit	200	...	...	...
Muriate of potash	...	100	100	100
Acid phosphate	600	1,000	...	600
Acid phosphate or bone meal ...	...	...	600	...
Sulphate of ammonia	...	100	100	...
[illegible]ry muck or other rich earth ...	...	...	600	...

app

Formulas for tobacco.

	No. 19.	No. 20.
	Pounds.	Pounds.
Stable manure	900	...
Fine horse or cow manure, rich mould, or similar material ...	...	900
Acid phosphate	500	...
Acid phosphate or dissolved bone	...	600
Fish scrap or tankage	...	350
Sulphate of ammonia	100	...
Sulphate of potash	300	150
Sulphate of magnesia	100	...
Plaster (gypsum)	100	...

The following dry mixture is recommended by the North Carolina Station for cotton and corn :

	Pounds.
Acid phosphate	800
Muriate of potash	100
Sulphate of ammonia	60
Finely pulverised manure from henhouses, hors e or cow stables	1,040
	2,000

In experiments on tomatoes, sweet potatoes, and peaches, annual applications of 10 tons per acre of barnyard manure, supplemented by 160 pounds of dissolved boneblack, 80 pounds of muriate of potash or sulphate of potash, and 100 pounds of nitrate of soda, supplied separately; and 20 tons of manure, with double the amounts of the other materials, have given good results.

The fermenting of peat with stable manure was formerly practised to a considerable extent. Where such a compost is desired the materials should be laid down in alternate layers in the proportion of about five parts of peat to one of manure.

LASTING OR CUMULATIVE EFFECT OF BARNYARD MANURE.

Barnyard manure is probably the most efficient means at the disposal of the farmer to permanently improve his soil. No other fertiliser possesses to so great a degree the power of restoring worn soils to productiveness and giving them lasting fertility. It accomplishes this result, however, not so much by the actual fertilising constituents which it supplies as by improving the physical properties of the soil, increasing the amount of humus, which is generally deficient in worn soils, improving its texture, and increasing its water-absorbing and water-holding power. Experiments have shown that the influence of manure may be perceptible twenty years after application. Observations at Rothamsted, England, during forty years on barley unmanured, manured continuously, and manured during the first twenty years only showed that "there was gradual exhaustion and reduction of produce without manure, and gradual accumulation and increase of produce with the annual application of farmyard manure. But when the application was stopped, although the effect of the residue from the previous applications was very marked, it somewhat rapidly diminished, notwithstanding that calculation showed an enormous accumulation of nitrogen as well as other constituents."

The yield, however, was maintained for twenty years considerably higher than that on the unmanured soil. Continuous manuring of wheat at the rate of 14 tons per acre annually for forty years resulted in an average increase of yield from year to year of one-fourth bushel per acre, or a total of about 10 bushels in forty years. While it is true that there is a constant increase in the productiveness of soil on which barn yard manure is applied regularly, it is not as great as the amounts applied would seem to justify. This is chiefly due to the fact, already explained, that the nitrogen is largely converted into slowly available forms.

SUMMARY.

(1) Barnyard manure is the most important manurial resource of the farm and should be carefully saved and used. It represents fertility drawn from the soil and must be returned to it if productiveness is to be maintained. In many cases it has been demonstrated that the value of the manure obtained in cattle feeding represents largely, if not entirely, the profit of feeding.

(2) There are sound scientific reasons for the high esteem in which this manure is held. It contains all the fertilising elements required by plants in forms that insure plentiful crops and permanent fertility to the soil. It not only enriches the soil with the nitrogen, phosphoric acid, and potash which it contains, but it also renders the stored-up materials of the soil, more available, improves the mechanical condition of the soil, makes it warmer, and enables it to retain more moisture or to draw it up from below.

(3) The amount and value of manure produced by different kinds of farm animals may be judged from the following figures, calculated to 1,000 pounds of live weight: Sheep, 34.1 pounds of manure per day, worth 7.2 cents; calves, 67.8 pounds, worth 6.7 cents; pigs, 83.6 pounds, worth 16.7 cents; cows, 74.1 pounds, worth 8 cents, and horses 48.8 pounds, worth 7.6 cents, basing calculations of value on market prices of commercial fertilisers, which probably gives results much too high. Making liberal allowance for these and other considerations, Prof. Roberts estimates that the value of the manure produced on a small farm carrying 4 horses, 20 cows, 50 sheep and 10 pigs during the seven winter months amounts to about $250.

(4) The urine is by far the most valuable part of the excreta of animals. It is especially rich in readily available nitrogen, which rapidly escapes into the ail if special precautions are not taken to prevent its loss. It is also rich in potash, but deficient in phosphoric acid. It should, as a rule, be used in connection with the solid dung, the one thus supplying the deficiencies of the other and making a more evenly balanced manure.

(5) Barnyard manure is a very variable substance. The more important conditions which determine its composition and value are (1) age and kind of animal, (2) quantity and quality of food, (3) proportion of litter, and (4) method of management and age. Mixed barnyard manure properly cared for may be assumed to have the following composition: Water, 75 per cent; nitrogen, 0.57 per cent; phosphoric acid, 0.3 per cent; potash, 0.57 per cent.

(6) Mature animals, neither gaining nor losing weight, excrete prac-

tically all the fertilising constituents consumed in the food. Growing animals and milch cows excrete from 50 to 75 per cent of the fertilising constituents of the food; fattening or working animals from 90 to 95 per cent. As regards the fertilising value of equal weights of manure in its normal condition, farm animals probably stand in the following order: Poultry, sheep, pigs, horses, cows.

(7) In a given class of animals the value of the manure is determined more by the nature of the food than by any other factor. The amounts of fertilising constituents in the manure stand in direct relation to those in the food. As regards the value of manure produced the concentrated feeding stuffs, such as meat scrap, cotton-seed meal, linseed meal, and wheat bran stand first, the leguminous plants (clover, peas, etc.) second, the grasses third, cereals (oats, corn, etc.) fourth, and root crops, such as turnips, beets, and mangel-wurzels last.

The nitrogen of the food exerts a greater influence on the quality of the manure than any other constituent. It is the most costly fertilising constituent, and is present in largest quantity. It undergoes more modifications in the animal stomach than the mineral constituents (potash and phosphoric acid), and rapidly escapes from the manure in fermentation. The secretion of urine increases with the increase of nitrogenous substances in the food, thus necessitating the use of larger amounts of litter and affecting both the amount and value of the manure. The use of watery foods, as is obvious, produces the same result.

(8) The deterioration of manure results from two chief causes, (*a*) fermentation, whereby nitrogen, either as ammonia or in the gaseous state, is set free, and (*b*) weathering or leaching, which involves a loss of the soluble fertilising constituents. The loss from destructive fermentation may be almost entirely prevented by the use of proper absorbents, and preservatives, such as gypsum, superphosphate, and kainit, and by keeping the manure moist and compact. Loss from leaching may be prevented by storage under cover or in pits. Extremes of moisture and temperature are to be avoided, and uniform and moderate fermentation is the object to be sought. To this end it is advisable to mix the manure from the different animals thoroughly in the heap.

(9) When practicable it is best to apply manure in the fresh condition. The disposition to be made of the manure of the farm (both fermented and unfermented) must be determined largely by the nature of the crop and soil. Where improvement of the mechanical condition of the soil is the principal object sought, fresh manure is best adapted for this purpose to heavy soils and well-rotted manure to light soils. Where prompt action of the fertilising constituents is desired, the best results will probably be obtained by applying fresh manure to the light soils, although excessive applications in this case should be avoided on account of the danger of "burning out" of the soil in dry seasons. Fresh manure has a forcing effect, and is better suited to grasses and forage plants than to plants grown for seed such as cereals. Direct applications to root crops, such as sugar beets, potatoes or tobacco, often prove injurious. The manure should be spread when carried to the field, and not left in heaps to leach.

The rate of application must be determined by individual circum-

stances. As a rule it is better to manure lightly and frequently than to apply a large amount at longer intervals.

(10) One of the best ways to utilise barnyard manure is to combine it with such materials as supplement and conserve its fertilising constituents. The best results are likely to be obtained by using commercial fertilising materials in connection with barnyard manure, either in compost or separately. As is well known barnyard manure is lasting in its effects, and in many cases need not be applied so frequently as the more soluble and quick-acting superphosphates, potash and nitrogen salts, etc.

FERNS: SYNOPTICAL LIST—XLVII.

Synoptical List, with descriptions, of the Ferns and Fern-Allies of Jamaica. By G. S. JENMAN, *Superintendent Botanical Garden, Demerara.*

74. *Polypodium angustifolium,* Swartz.—Rootstock short-creeping, ¼ in. thick, more or less clothed with reticulated acuminate scales; stipites numerous, crowded, 1½-3 in. l., flattish, with one to several pair of indistinct lateral glands to the narrow decurrent wings; fronds 1-2 ft. l. ¼-1 in. w. curved or sub-pendent, narrowly acuminate, long tapering at the base; coriaceous, naked, glossy, the underside paler, the margins entire, often undulate-repand, cartilaginous-edged, the rachis stramineous, slender; primary veins hardly stronger than the intermediary, the areolæ directed toward the margin, each containing a single free or anastomosing soriferous veinlet; sori terminal or dorsal, one to each of the larger areolæ. *P. tæneosum,* Willd.

a. var. P. amphosternon, Kunze.—Rootstock more elongated; stipites longer, less crowded and fewer; fronds ¾-2 in w.; texture less coriaceous; areolæ and sori more copious. *P. fasciale,* Willd.

Common on trees and rocks up to 5,000 feet altitude, very variable in width; the narrowest forms being only two lines wide, with a single series of areolæ and sori on each side of the rachis, while the broader states have two to three series. The texture is very coriaceous, and the edges are often revolute. The venation is abnormal and intermediate between *Campyloneuron* and *Goniophlebium.* In narrow forms it quite agrees with the latter sub-genus. *a* is found on rocks at 6,000 ft. altitude; its larger state gives it a distinct appearance, but in venation it is quite identical with the type, the broader fronded forms of which imperceptibly pass into it.

75. *P. piloselloides,* Linn.—Rootstock very slender, flexuose, wide-creeping, freely branched, forming a net-work, clothed with fine pale subsquarrose acuminate scales; stipites scattered ½–1½ in. l., slender, finely fibrillose scaly; fronds dimorphous; subcoriaceous, opaque when dry, dark green, freely clothed with scattered minute peltate—caudate scales, which have a brown disk at the base; barren oblong lanceolate or ovate-lanceolate, the apex rounded acute or acuminate, the base usually cuneate, 1–2 in. l, ½–¾ in. b., fertile linear-lanceolate, 1–2½ in. l. 2–3 li. b. margins entire; veins generally obscure, forming a row of large costal areolæ with free included branches and smaller exterior meshes; sori large, confined to the costal areolæ, terminal on the in-

cluded veinlets, receptacles bristling with copious brown hairs. Pl. Fil. t. 118. *Craspedaria*, Fee, *Lopholepis*, J. Smith.

Common from the lowlands up to 5,000 feet altitude, growing on stones, banks and the stems and branches of trees, in open places. The rootstock when divested of its scales is hardly thicker than strong thread. The barren fronds vary considerably in shape, in the largest state they are ovate-lanceolate, pointed, 2 in. l. on slender petioles nearly as long; in the smallest they are ovate-oblong, rounded, $\frac{1}{2}$ in. l. the stipites only 1–2 li. l. Generally the barren and fertile fronds are distinct in form, but not uniformly. In *P. ciliatum*, Willd. the fertile fronds are linear and so narrow that the two lines of sori touch on the inside, and project on the outside over the margins, giving a moniliform aspect to the margins.

76. *P. vacciniifolium*, Fisch & Langsd.—Rootstock as thick as strong cord, wide-creeping and freely branched, very densely clothed with long fibrillose fine reddish scales which eventually become pale; fronds scattered, copious, coriaceous, glabrous, bright green, glossy on the upper side, subsessile or very shortly petioled, dimorphous; barren oblong, rounded at the top, the base cuneate, $\frac{1}{2}$–$1\frac{1}{2}$ in. l, $\frac{1}{4}$–$\frac{1}{2}$ in. w.; fertile linear, 1–$4\frac{1}{2}$ in. l. $1\frac{1}{2}$–$2\frac{1}{2}$ li. b., the margins even, veins immersed, costal areolæ large, each containing a free veinlet, exterior meshes smaller, sori copious in long medial lines, the sporangia mixed with reddish fibrillæ.—*Lopholepis*, J. Smith.

Spreading abundantly over the branches and trunks of trees, usually at low elevations. This has a stouter, more densely clothed and wider diffused rootstock than any of the other species of the group. In a barren state the fronds resemble those of the next species, but are much smaller. In this condition the different venation is a reliable distinguishing character. It presents however nearly at all times the two kinds of fronds, when the rush-like fertile ones are so distinct as to distinguish it at sight. I have only seen Jamaica specimens in the Kew Herbarium; collected by Bancroft.

77. *P. lycopodioides*, Linn.—Rootstock cord-like, wide-creeping, branched and forming a copious net-work, densely coated with fine appressed scales, which are pale at first but ultimately dark; fronds coriaceous, naked, a bright glossy green, scattered, with hardly any, or very short, distinct petioles, 4–7 in. l. $\frac{1}{3}$rd–$\frac{3}{4}$ths in. w., oblong or linear-lanceolate, acute or acuminate at the apex, the base tapering and decurrent on the short stipites, barren ones shorter and broader than the fertile, margins entire; primary veins more or less distinct, but evanescent before reaching the margins, fertile areolæ medial, with included free or united branches, and smaller costal and exterior meshes; sori sunk, the opposite surface papillose, medial or nearer the margins, terminal on a single, or two or more united enclosed veinlets.—Pl. Fil. t. 119.

a var *P. salcifolium* Willd.—Fronds usually rather narrower, the sterile and fertile conform, or less distinct,—Pl. Fil. t. 121.

Common, abundant at low elevations but attaining 5,000 ft. alt.; spreading over the trunks and branches, of trees, and on rocks and banks, chiefly in exposed places, but also in loose forests. Variable in size, and usually smaller at the higher elevations. In the type the barren and fertile fronds are generally distinct and different in shape

(not shown in Pl's. fig.) but casually both forms are fertile. In drying it turns nearly black. The conform barren and fertile fronds of *a* led Willdenow, Grisebach and others to regard it as a distinct species.

78. *P. Swartzii*, Baker.—Rootstock slender, wide-creeping, branched, clothed with fine linear acuminate fulvous scales, which in time become dark; fronds scattered, chartaceous or membrano-chartaceous, pellucid, naked, or sometimes glandulose beneath, usually pale green, stipitate, or more distinctly petiolate, 3-6 in. 1 ¼ - ½ in. w., tapering both ways, the apex acuminate or bluntish, the base decurrent on the slender stipites, the margins subentire or sinuate, rarely deeply lobate; veins fine, but evident, areolæ 1 - 3 serial, fertile meshes enlarged, usually central, with included free or united branches, marginal branches also free or united; sori-medial, slightly depressed, terminal on a single or two or three united veinlets. Pl. Fil. t. 122, *P. serpens*, Swartz.

Common in the limestone districts up to 2,000 ft. altitude on rocks and trees; variable in size, texture, venation, and the more or less uneven margins. In some cases the fronds are irregularly lobate. The venation is equally variable, and in instances resembles that of *Goniophlebium*. the costal series of narrow barren areolæ being absent. The rootstock too is very distinct and somewhat peculiar. It is shrivelled and striated longitudinally and the branches are usually short or rudimentary. Mixed with the scales at intervals are small acuminate dark spur-like appendages. *P. runcinatum*, Desv. is represented in Plumier's figure quoted above. The name *serpens* was first used by Forster for an Australian species. Swartz unwittingly used the term later for this Jamaica plant. Heward not knowing this, and taking the same plant for a new species described it in the Magazine of Natural History, Sept., 1838, naming it *P. exiguum*. Subsequently Grisebach unaware of this, used the same designation for another Jamaica Polypod., after which Baker discovering Swartz's name preoccupied by Forster's plant called it *P. Swartzii*. Heward's name has therefore priority, but its adoption would involve renaming Grisebach's plant, a plant for which the term is entirely appropriate, and, as Heward's authority has hardly been known, I think the matter had better be left as it is.

79. *P. lanceolatum*, Linn.—Rootstock slender, free-creeping, clothed with narrow pale-margined scales; stipites scattered, 2-4 in. l., slender, dark-brown, naked or with a few deciduous peltate scales, margined above; fronds very coriaceous and stiff, more or less freely coated with minute dark-centred peltate fimbriate-edged appressed scales, beneath which they are a dark brownish-green, lanceolate or linear-lanceolate, 4-12 in. l. ½-1¼ in. b., tapering freely at both ends, margins entire or sinuate, rachis dark coloured beneath; veins immersed copiously reticulated, forming large costal areolæ, with included and exterior smaller meshes; sori large, 2-3 li. b., medial, oval or oblong, rarely round, depressed, contained in the large areolæ; sporangia mixed with short dense scales, which form permanent pads. *P. lepidotum*, Willd. *P. ensifolia*. Hook. Fl. Exot. t. 62.

a var. *Elisabethæ*, Jenm.—Fronds uniformly lobed on both sides.

Common from 2,500–6,000 ft. alt. in exposed situations on rocks, banks and trees. A very distinct plant. In narrow fronds the large sori occupy the whole space between the midrib and margins. In the irregularly lobed states there is often a partial second row, and the

short lobes have sometimes a double series. In many cases it is confined to the upper half of the frond. The upper surface is usually pitted with elliptical depressions over the sori. *a* is found in the region of the Govt. Cinchona Plantations.

Tribe XI. Grammitideæ.

Sori arcuate, oblong, linear-oblong, or linear, short or more or less elongated and continuous, situated on the veins, which form the receptacles, and disposed variously in simple, forked or confluent and reticulated lines, superficial or immersed; quite destitute of involucres; sporangia stalked, compressed, arched by an incomplete vertical jointed band, splitting transversely at maturity; fronds from less than an inch to several feet long, entire or variously cut and often multifid; venation simple or forked and free, united or copiously reticulated.

The plants of this tribe form a moderately limited group representing one fairly extensive genus and five very small ones, which are loosely connected by the single tribal character of naked elongated sori. The large majority inhabit regions within the tropics of both Hemispheres, only a few extending beyond, chiefly in the south temperate zone.

Sori transversely oblong or arcuate; fronds pinnate; primary veins costate, the transverse arcuate.—	1. Meniscium.
Sori oblong, linear-oblong or linear; fronds simple or compound; veins free. -	2. Gymnogramme
Sori linear-oblong, immersed in the parenchyma; fronds simple; veins united.—	3. Enterosora.
Sori reticulated; fronds palmate or pinnate.—	4. Hemionites.
Sori sparingly diffused over the under surface; fronds simple; veins reticulated.—	5. Anetium.
Sori reticulated or zigzag in oblong angular meshes; fronds simple; veins areolate.—	6. Antrophyum.

Genus XXVI. Meiscium, Schreb.

Sori oblong, curved, dorsal on the arc of the united transverse veinlets; primary veins costate, raised, pinnatiform, connected by opposite united curved or angled branches, which form multiserial narrow transverse areolæ containing each a free or attached erect veinule; fronds rarely simple, chiefly pinnate.

All the species of this genus within the geographical scope of this Flora are pinnate. The sori, though strictly confined to the transverse veins, become ultimately confluent partly or quite concealing the under surface of the fronds. The outer fronds are generally barren and the inner fertile; and the united veinlets in the former are angled while in the latter they are arcuate. Generally the species are well defined, and they vary only in size and form. They are terrestrial plants preferring moist or wet situations. About a score of species altogether, are known.

Fronds dimorphous, the pinnæ of the fertile reduced, and the sori covering nearly the whole surface.—	1. M. angustifolium.
Fertile fronds not much modified in size of pinnæ, and sori not generally confluent.—	2. M. serratum.
	3. M. reticulatum.

1. *M. angustifolium*, Willd.—Rootstock fasciculate, decumbent, short-creeping, forming with the abundant rootlets matted masses; stipites contiguous or subtufted, 10 – 15 in. l strong, slightly pubescent, dark coloured below and clothed with a few deciduous scales; fronds pinnate 1–1½ ft. l. 5–10 or 12 in. w. barren and fertile distinct, subcoriaceous, naked except the costæ which are finely coated with puberulæ, dark green, composed of numerous lateral pinnæ and a similar terminal one, rachis light coloured channelled, finely pubescent; pinnæ spreading or erecto-spreading, approximate but not close, linear-lanceolate, tapering and very acuminate, the base cuneate and stipitate, 3–6 in. l. ⅜ths–⅝ths in. w., lowest pair usually a little reduced, margins entire; sori copious, confluent and covering the under surface at maturity; veins close, areolæ 6–8–serial. Sl. Hist. p. 84, t. 40; Herb p. 86. *M sorbifolium*, Eat., *Phegopteris*, Mett.

Common on wet rocks in the beds of rivers among the lower hills, and widely diffused through the island. This is the smallest of the West Indian species, with narrow willow-like leaflets, the fertile fronds smaller than the barren, with narrower pinnæ on rather longer stipites. The plants are often submerged by the rising of the rivers in wet weather, and the matted roots are developed to hold their position in the heavy drag of the rushing water on such occasions.

2. *M. serratum.*—Cav.—Rootstock strong, decumbent, short-creeping; stipites contiguous, erect, 2 - 3 ft. l; channelled, naked, dark coloured at the base, pale above; fronds chartaceous, naked, or slightly ciliate on the ribs and veins beneath, dark green, paler beneath, 2-4 ft, l. ¾ - 1¼ ft. w., with a distinct terminal pinna and numerous more or less distinct spreading or erecto-spreading lateral ones, which are 4 - 9 in. l. ¾ - 1½ in. w., acuminate serrate or crenate-serrate margined, the base plain rounded or cuneate and stipitate, rachis and costæ stramineous, the former puberulous on the face; venation conspicuous on both sides, areolæ narrow, numerous; sori sparse, becoming confluent and diffused over the surface.

Common in swampy ground at low elevations: most plentiful in the western parishes; more or less aquatic. A taller plant usually than *reticulatum*, with more slender stems, and narrower pinnæ with uniformly serrated margins. The latter is its most reliable character. The pinnæ often produce buds in the axils. The sori are less copious in sporangia than in any of the other species, and it has a reddish tinge.

3. *M. reticulatum*, Swartz.—Rootstock stout, decumbent, short-creeping; stipites tufted strong, erect, 1½-3 ft. l, naked, brown or pale coloured; fronds 1½-3 ft. l. 1-1½ ft. w. oblong-lanceolate, subcoriaceous, naked, or beneath puberulous, and paler than above, rachis strong, naked, light or dark brown; pinnæ numerous spreading, 2-3 in. apart, oblique, the lower ones largest, gradually reduced upwards to the similar free terminal one,, the former 5-10in. l. 1-2¼ in. w., broadest at the base, which is rounded and stipitate or sessile, thence tapering outwards to the acuminate point; margins entire or slightly crenate; venation conspicuous, areolæ very numerous; sori copious, confluent or nearly so. Pl. Fil. t. 110. Polypodium, Linn.

Common in moist, generally open, or little shaded situations at low elevations. A strong robust species, with about 10-15 pinnæ to a side which are generally large and broad at the base, from whence they

taper outwards to the acuminate point. The fertile fronds are taller and on longer stipites than the sterile.

Genus XXVII. Gymnogramme, Desv.

Sori oblong, linear-oblong or linear, situated on the back of the veins, superficial or somewhat immersed; veins free or united; fronds ranging from simple to decompound, naked, ciliate. or coated beneath with white or yellow powder.

This is a genus of rather considerable extent, in which very dissimilar plants are associated by the common character of superficial or immersed naked elongated sori. In the form and arrangement of the sori it resembles *Asplenium*, of which in this division it may be regarded the anologue, differing by the absence of involucres. The farinose section is remarkable for a fecundity equalled by very few other plants in the family. The species are about equally divided between the old and the new World and are chiefly tropical. They occupy banks and usually open, generally fully exposed, situations, and are represented abundantly from the lowest to the highest elevations.

Fronds flabellato-digitate.—	1. G. pumila.
Fronds simply pinnate.—	2. G. rufa.
Fronds bipinnatifid —	3. G. gracilis.
	4. G. consimilis.
	5. G. diplazoides.
Fronds decompound.—	6. G. chærophylla.
	7. G. schizophylla.
Fronds coated with powder beneath.—	
Pinnæ trifoliate.—	8. G. trifoliata.
Fronds decompound.—	9 G. tartarea.
	10. G. triangulata.
	11. G. calomelanos.
	12. G. sulphurea.

1. *G. pumila*, Spreng.—Rootstock filiform, erect, clothed with hair-like reticulated ciliate-edged brown scales; fronds membranous, glossy, naked, green, tufted, few, v-shaped or flabellate-cuneate, occasionally linear-cuneate, $\frac{1}{2}$-$1\frac{1}{2}$ in. l. 1-6 li. w. at the apex, the lateral margins entire, the outer jagged or deeply incised, often into narrow spreading sharp-pointed segments and gradually attenuated downwards to a slender filamentose base with hardly any clear stipites; veins close, flabellate, dichotomously forked; sori linear, becoming confluent laterally, forming one or more broadish patches on the more entire portion of the outer parts of the fronds. Hook. 2nd Cent. Ferns t. 8. *Hecistopteris*, J. Smith.

var. *a*.—Fronds shorter and broader and deeply cut into spreading linear segments, which divaricate like stag's horns.

Communal, forming large or small patches in moss on the trunks of trees; gathered by March, whose specimens are at Kew. It varies greatly in shape and degree of cutting from linear with two or three sharp segments or teeth at the apex, to broadly palmate flabellate and multifidly cut to the base. The lines of sori are at first separate but ultimately unite laterally, forming apparently amorphous patches; but in var. *a* there are only one or two lines to each narrow segment.

2. *G. rufa*, Desv.—Rootstock fibrous, upright; stipites tufted, erect, chestnut brown, polished, rusty villose, 4-10 in. l.; fronds pinnate, thin

and rather soft, surfaces slightly pubescent, under paler than the upper, oblong-lanceolate, 1-1¼ ft. l. 4-5 in. w.; rachis like stipes, but less villose; pinnæ entire, spreading horizontally, oblong-lanceolate, subdistant, stipitate, and articulated at the top of the pedicels, 1-2½ in. l. ¼-1 in. w. rounded or subcordate at the base, shortly acuminate, 6-9 to a side with a similar terminal one, the lowest pair not or very little smaller, midrib slender; veins close, much curved, in fascicles, two or three times forked, fine, terminating within the even margin; sori copious, linear on the veins, extending usually from the midrib to near the edge. *Acrostichum*, Sw., *Neurogramme*, Link. *G. acuminata*, Klf.

Common on dry banks below 2,000 ft. altitude; especially abundant about Hope and Gordon Town; well marked by the simply pinnate habit and the copious rusty pubescence. The stipites and rachises, though not slender, are very fragile. They stand dead around the live fronds, spurred at intervals with the short pedicels of the pinnæ which have all dropped away. The latter are about 10–15 to a side. The upper ones are very little reduced, passing abruptly into the larger free terminal segment.

3. *G. gracilis*, Heward.—Rootstock erect or oblique, scaly; stipites cæspitose, short, scaly; fronds bipinnatifid, chartaceous or subcoriaceous, slightly ciliate, oblong-lanceolate, usually spreading or pendent, 2–4 ft. l. ¾–1½ ft. w., acuminate, the base gradually reduced; rachis rather slender, light brown, channelled, more or less ciliate or pubescent, as are the costæ; pinnæ spreading, sessile, very numerous, contiguous above, below subdistant or distant and dwindling nearly to the base of the petioles into very minute segments, central ones 5–10 in. l. 1–1¾ in. w., very acuminate, pinnatifid nearly to the costæ; segments linear oblong, straight or falcate, blunt, close, or in the larger states with a rounded sinus between, less than ½–1 in. l. 1½–2 li. w.; veins oblique, 10–16 to a side; sori close to the margins, the edges of which are entire and often reflexed.—*Polypodium Hewardii*, Gr.

Very abundant on banks at 4,000-6,000 ft. alt. The stipites usually are only 1 - 3 in. l. below the dwindling segment-like pinnæ. The sori are short, and so near the margins that the reflexed edges partially cover them. The lowest pair of opposite veins enter above the sinus. This and the two following have quite the habit and aspect of common bipinnatifid *Nephrodia*.

4. *G. consimilis*, Fée.—Rootstock short, erect, scaly; stipites cæspitose, very short (1–3 in. l.) brown or darked coloured, scaly, fronds bipinnatifid, chartaceous, pubescent, dull green, lanceolate, or ovate lanceolate, acuminate, gradually reduced at the base, 2 - 3 ft. l. 8 - 12 in. w., spreading or prostrate; pinnæ spreading, oblique, apart, the lower ones, which dwindle at the base to mere segments, usually distant, 4 - 6 in. l. ¾ - 1 in. w. sessile, very acuminate, cut almost to the costæ into blunt or acute, straight or subfalcate narrow segments, ⅓rd - ½ in. l. 1½ l. b., the bases very slightly dilated, with an acute or rounded sinus between; rachis slender, channelled, brown, pubescent; veins oblique, 9 - 12 to a side; sori medial, a little short of both midrib and margins.

Common in the parishes of St. Mary and St. Andrew, in woods or shady places, near, or not distant from, the banks of rivers, at 500-1,000 ft. altitude. This differs from the preceding and following species

by its medial sori and more pubescent surfaces It is smaller and often relatively broader than *gracilis*, of a duller colour, and with longer sori. The margins are not, as a rule, reflexed, and the lowest pair of opposite veins enter them above the sinus.

5. *G. diplazioides*, Desv.—Rootstock erect, scaly; stipites cæspitose, erect, 6-12 in. l., brown, dark-coloured at the base with a few deciduous scales: fronds bipinnatifid, chartaceous, pellucid, nearly glabrous, clear green, paler beneath, erect, lanceolate, 2-3 ft. l. 6-9 in. w. acuminate, reduced at the base; rachis brown, channelled, puberulous on the face; pinnæ spreading, distant or subdistant, 3-4½ in. l. ¾ in. w. sessile and usually broadest at the base, the apex entire and more acute than acuminate, cut down about ¾ths to the costæ into flat broadish blunt or rounded segments which are widest at the base, and 2 li. b., the lowest pair usually enlarged, veins 6-9 to a side, the lower ones often forked, the opposite basal pair entering the sinus; sori nearer the the margin than midrib, linear on the lower veins and double when they are forked.—*Phegopteris Duchassagniana*, Fée. Fil. Ant. t. 14 fig. 3.

Frequent by the open way side in the in the neighbourhood of second-breakfast spring, near Mount Moses, St. Andrew at 2,000-3,000 ft. altitude. This differs from the other two species by its erect habit; longer stipites, few reduced pinnæ at the base, which, too, are not so small, clear coloured and nearly naked surfaces, less deeply pinnatifid and acuminate pinnæ, broader segments, the lowest pair usually enlarged, fewer and more open veins, the lowest pair of which meet at the sinus and are often forked, with invariably longer sori than those above. The sori show prominently on the clear pale under surface.

6. *G. chærophylla*, Desv.—Rootstock short, fibrous, upright; stipites tufted, few or many, erect, 4-6 in. l., slender, the base chestnut-brown, above this green, naked; fronds subdeltoid, membrano-herbaceous, naked, dark-green above, 3-4 in. each way, tri-quadri-pinnate; lowest pair pinnæ largest, and rather distant from the next above, all, erecto-spreading and freely petiolate; pinnulæ also stipitate; tertiary segments flabellate-cuneate, 1½-2½ li. b., once or twice cut to the base into similar segments, the outer margin freely toothed; rachis and costæ flat and margined, slender, green; veins dichotomously forked, flabellate, terminating in the final teeth, which are a ¼ li. w.; sori copious, linear, occupying all the veins their entire length, and confluent or nearly so laterally, pale or brown coloured. Pl. Fil. t. 50, C. Hooker and Grev. Icon. t. 45. *G. leptophylla*, Eat. *Anogramme*, Lk.

Frequent at 4,000-5,000 ft. alt. on damp banks, rocks and waysides and generally plentiful where found. This is a tender herbaceous plant, of great fecundity, but short individual duration, and hence regarded as an annual. It is most abundantly soriferous, the underside being covered with the contiguous almost confluent lines of pale brown sporangia. The lowest pair of pinnæ are often so much larger and distant from the others that the fronds in these instances appear trifoliate.

7. *G. schizophylla*, Baker.—Rootstock fibrous, erect or oblique; stipites tufted, slender, erect, early farinose, dark chestnut-brown, polished, 1-3 in. l; fronds membrano-herbaceous, naked, bright green, lanceolate or oblong-lanceolate, ½-1 or 1½ ft. l. 2-3 or 5 in. w. tri-quadri-pinnate; rachis slender, channelled, castaneous, polished, generally producing a farinose but, and often forked near the apex; pinnæ numerous, conti-

guous spreading, 1½-3 in. l. ¾-1 in. or over w. lower ones usually reduced; pinnulæ very freely and deeply cut, ultimately into delicate-spreading 2-fid-cuneate segments with narrow emarginate linear divisions 2¼-½ li. w., costæ filiform and brown at the base, the outer part flat, margined and green, as are the ribs of the other divisions; veins pellucid, forked, simple in the final segments; sori copious, medial, one to each segment. Hook. Icon. t. 1682.

Infrequent at 4,000–4,500 ft. altitude on open or shady stony ground; rediscovered in 1875 at Old England, St. David, where it was collected in 1853 by Miss Taylor, whose collection was not examined however till 30 years later. It is found also in parts of the Government Cinchona Plantation. This is the most finely cut species of all. The fronds resmble very much the pinnulæ of *Davallia fumarioides.* They sometimes extend considerably by the bud which is produced near the top.

8. *G trifoliata*, Desv.—Rootstock fibrous, scaly, erect or oblique; stipites tufted, stiff, erect, 9–18 in. l., blackish, polished, faintly channelled, fibrillose at the base; fronds 2–4 ft. l., 4–6 in. w., erect, firm or subcoriaceous, naked and dark bright green above, beneath coated with yellow farina; rachis stiff, coloured like the stipites, slightly scaly and farinose at first, ultimately naked; pinnæ numerous, distant, petiolate, digitate composed of 1–3 spreading linear, acuminate, pinnulæ, which are 3–4 in. l. and ¼ in. w., those of the lower pinnæ usually barren, of the upper fertile, each with a prominent raised costa beneath; the edge very finely crenate-serrate; veins fine, curved, close, dichotomously forked; sori linear, confluent.—Pl. Fil. t. 144. Hooker Gard. Ferns t. 4.

Common, gregarious in open marshy places below 2,500 ft. alt; generally by the sides of permanent trickling streams. The upper pinnæ are simple, the next below 2-foliate, those below these, which are the large majority, 3-foliate, the central pinnule in each pinnæ being the largest. The veins are so close that the sori quite cover the surface. It is a stiffly erect, tall and robust species, that forms generally large communities, often crowded together from the plants which have grown from viviparous buds produced on the roots.

9. *G. tartarea*, Desv..—Rootstock fibrous, densely scaly, erect or oblique; stipites cæspitose, usually spreading, strong, ½ - 1½ ft. l. castaneous or blackish, polished, channelled, deciduously scaly at the base; fronds 1 - 2½ ft. l. ¼ - 1¼ ft. w., subcoriaceous, naked and dark green above, beneath densely coated with white powder, usually widest at the base, varying from lanceolate to ovate-acuminate, bi-tripinnate; pinnæ numerous, spreading or erecto-spreading, more or less distant below, sessile, or the lower ones stipitate, lanceolate-acuminate, 3 - 9 in. l. ½ - 2½ in. w.; pinnulæ contiguous or apart, oblong, acute or rounded, adnate to the costæ or the inferior ones free, entire, auricled at the base, or more or less lobed or pinnatifid, ¼ - 1½ in. l. 1½ - 6 li. w., the margins entire and rather reflexed; rachis strong, channelled, polished and coloured like the stipites; veins 1 - 3 times forked, sori copious, confluent and often covering the surface.—*G. dealbata*, Link. *Hemionitis*, Willd. *Acrostichum*, Swartz.

Abundant in open places. banks and dry woods from 2,000-6,000 ft. alt.; very variable in size and cutting. The normal state is nearly

simply bipinnate, and a larger fully tripinnate state is found at the higher altitudes. The powder is as a rule very white, but there is a beautiful golden state in Dominica.

G. ornithopteris, Kl. also gathered in Jamaica, is more rigid than the type, the pinnæ resembling pinnulæ of *Pteris aquilina*, the edges of the segments revolute. This is a much stiffer plant than *calomelanos*, of spreading (not erect) habit, with less cut broader more obtuse segments and whiter powder. They occupy, too, separate zones in altitude.

10. *G triangulata*, Jenm.—Stipites tufted from an erect fibrous scaly rootstock, slender, 1-1½ ft. l., very dark, polished, deciduously scaly at the base; rachis slender like-coloured, channelled; fronds tripinnatifid ovate-deltoid, acuminate, broadest at the base, spreading, ¾-1½ ft. l. ½-1 ft. w., firm, chartaceous, upper surface bright clear green, under sparingly coated with white powder; pinnæ spreading, petiolate, the lowest pair largest and rather deeper on the under side, 4-6 in. l. 1½-2 in. w., lanceolate-acuminate; pinnulæ oblong, broadly rounded at the lobed or subentire apex, ½-1 in. l. ¼-⅓rd in w. uniformly pinnatifid, final segments apart, short, rather ovate or rounded narrowed or cuneate at the base; 1-1½ li b. and d. outer edge entire or dentate; veins pellucid, dichotomously forked, flabellate; sori linear, confluent.

Infrequent at 4,000 ft. attitude; gathered at Moody's Gap, St. Andrew. A broader less coriaceous and more freely cut plant than *tartarea*, to which it is more closely allied than to *calomelanos*, with the final segments not broadly adnate as in that species, but narrowed or more or less free at the base. It is uniformly tripinnatifid, and shows hardly any variation in its features. Of the three silver species it is much the prettiest. All the vascular parts are relatively slender, the lower pinnæ are subdistant and the upper ones are not close, and generally the fronds narrow directly from the base upwards. The slender costæ are rather flexuose, and flat and margined in the outer part. The rachis, too, is often to the same slight degree flexuose, at the top. It differs from *G. peruviana*, which species it most nearly approaches by being more lax in habit, and having no powder on the upper surface. No golden form has yet been found but should it would be the most lovely of all golden ferns.

11. *G. calomelanos*, Kaulf.—Rootstock fibrous, scaly, erect; stipites densely tufted, erect, polished, blackish, or dark castaneous, with a few deciduous scales at the base, 1-2 ft. l.; fronds erect 1-2 ft. l. ¼-1 ft. w. lanceolate or ovate-lanceolate, acuminate, chartaceous, naked and dark glossy green above, beneath white or grayish with copious farina; bi-tripinnatifid; rachis channelled, polished and coloured-like the stipites; pinnæ numerous, erecto-spreading, more or less distant below, petiolate, lanceolate-acuminate, 3-6 in. l. 1-2 in. b., pinnulæ contiguous or subdistant sessile and cuneate, acute-pointed or sometimes acuminate, varying from oblong to linear-lanceolate, simply toothed or deeply pinnatifid in the lower two-thirds, the outer part entire, ½-1¼ in. l., 2-4 li. w., lobes acute, the lowest largest; veins close, curved, once or twice forked; sori linear, confluent, covering the whole surface at maturity. Pl. Fil. t. 40.

var. a. *G. Martensii*, Bory.—Fronds bipinnate; pinnulæ ovate-oblong,

entire or the inferior lobed on one or both sides at the base; powder pale yellow.

var b. *G. chrysophylla*, Kaulf.—Fronds uniformly tripinnate; stipitate and rachises castaneous; powder deep yellow. Pl. Fil. t. 44.

Abundant in the lowlands and among the lower hills throughout the island, on open banks and exposed rocky places fully open to the sun; a very hardy plant, found from the wettest districts to the arid plains of Liguanea. Distinguished from its allies by the erect habit, sharp-pointed segments, and more herbaceous texture. *a* is usually smaller than the type, and reaches a higher mountain elevation. This and *b* are abundant at the old mines near Hope and Gordon Town. The latter is as large as the type.

12. *G. sulphurea*, Desv.—Stipites densely tufted from a fibrous erect or oblique rootstock, slender, castaneous, glossy, 2–4 in. l.; fronds spreading, lanceolate, or the larger ovate-lanceolate, acuminate, herbaceous, upperside naked and bright green, under densely covered with yellow powder; ½–1½ ft. l. 3–6 in. w., bi-tripinnatifid, somewhat reduced at the base, the rachis slender, castaneous, polished; pinnæ spreading or erecto-spreading, distant below, nearly sessile, lanceolate, 1½–4 in. l ½–1 in w.; pinnulæ ¼–½ in. l. 2–4 li. w., ovate-oblong, blunt or rounded and dentate at the apex, widest at the base, lobed or pinnatifid; tertiary segments ovate-oblong or the lower flabellate cuneate, 1–2 li. w. and d., dentate or inciso-dentate, the teeth retuse; veins forked, very oblique, pinnate in the pinnulae: sori oblong often confluent. —Pl. Fil. t. 48. B.

a. *G. Wilsoni*, J. Sm.—Fronds 3–5 in. l. ¾–1¼ in. w. short-petioled; rachis margined in the upper part; pinnae and segments close, somewhat crispate, freely soriferous, powder not copious.

Frequent on damp banks and under the shade of rocks from the lowlands up to 4,500 ft. alti.; a much more delicate and slender plant than any of the yellow states of *calomelanos*, with shorter sori, obtuse lobes, and deeper coloured powder. Of the small variety, *G. Wilsoni*, J. Smith, there are specimens both in the Kew and British Museum Herbaria collected by Wilson "near Arntully Gap, St. David," and I have gathered it myself at several places above 3,000 ft. alt. It is often nearly devoid of powder, more leafy and deeply incised, with sharper and more emarginate teeth than the type. Wilson says it does not grow larger than his specimens, which are, 3 - 4 in. l.and an inch or less wide. It varies, however, in size and my specimens exceed his, but it is never large.

Genus XXVIII. Enterosora, Baker.

Sori linear-oblong. immersed on the veins, within slits of the parenchyma of equal length, which at first quite enclose it with connivent edges but are subsequently open, forming one or two irregular series on each side of the midrib, directed obliquely to the margin; veins forked, oblique, the branches more or less uniting at the margin; fronds simple.

A remarkable monotypic genus, that differs from the rest of this group, and might therefore be included in the next, in having the sori enclosed within the parenchyma in slit-like cavities of the cuticle, so that when young, as seen held up to the light it seems to be quite inside the frond.

E. Campbellii, Baker.—Rootstock as thick as a quill or less, short or elongated, fibrous below, the apex freely clothed with small brown reticulated scales; stipites tufted, 3-5 in. l. wiry, dark brown, sparsely clothed with spreading brown hairs, articulated and clavate at the base; fronds linear-oblong, or oblanceolate, 3-6 in. l. ½-1 in. w. coriaceous, pellucid, slightly ciliate at first, chiefly on the margins, at length glabrous; apex obtuse, the sides even sinuate or lobate; midrib and veins concealed in the parenchyma, the latter very oblique, branched, the ends united within the margin; sori 1-1½ li. l. oblique in 1-2 series chiefly in the upper half or two-thirds of the frond, immersed in slit-like cavities, the edges of which at length open and abundantly reveal the ruddy erupting sporangia. Baker in Trans. Linn. Soc. Ser. 2. Bot. vol. II, p. 294, Pl 55. *E. Fawcettii*, Jenm. in Gard. Chron. 20th Aug., 1895.

Rare on the tops of high trees in the forests where *Lælia monophylla* grows, Rose Hill and Green Hill Wood, St. Andrew Parish. The species was first gathered on Roraima, British Guiana in 1884 and in Jamaica three years later. Better Jamaica material gathered recently (1895) show that the plants from the two countries are the same, only differing, partly, in vestiture and size. The fronds are occasionally forked apically or laterally or both, and possess a very close general resemblance to *Polypodium trifurcatum*, Linn. with which it grows at Roraima, and for which indeed it was mistaken when first gathered. The sori are sometimes on the free veins enclosed in the areolae of the connecting branches and again on the latter.

Genus XXIX Hemionitis, Linn.

Sori in continuous, forked or reticulated lines, superficial on the veins, the entire ramification of which is sporangiferous; veins anastomosing, little or much reticulated; fronds entire palmate or pinnate.

Hemionitis differs from *Gymnogramme* by the sori being continuous and more or less reticulated and coextensive with the venation. It is a small tropical genus, of less than a dozen species, half of which belong to the New World; and the rest to India, Java and Fiji. The plants are relatively of small size or stature, and grow in open situations on banks or rocks.

Fronds palmate.—	1. H. palmata.
Fronds pinnate.—	2. H. pinnata.

1. *H. palmata*, Linn.—Rootstock erect, fibrous, rather slender, clothed with narrow tawny scales; stipites tufted, erect, ½-1 ft. l. dark and rather glossy, deciduously villose, scaly at the base; fronds membrano-herbaceous, densely pellucid dotted, dark green, tawny-villose; palmatifid, 3-5 inches each way, composed of 5 acute diverging nearly equal divisions, that are ½-1¼ in. w. 1-2½ in. l. entire or cut into broad rounded appressed shallow lobes; veins copiously reticulated; sori occupying the entire venation, forming copious elevated areolæ, which gradually diminish outwards to the margins; barren fronds prostrate, smaller, often only tripartite, with rounded lobes viviparous in the sinuses, or much shorter slender stipites.—Pl. Fil. t. 151. Sl. Herb. p. 45. Hook Fil. Exot. t. 53.

Common on open exposed banks below 2,000 ft. attitude. Well

marked by the pedate-palmate form of the fronds and copiously reticulated venation and elevated sori. Though the stipites are stiff they are fragile, and easily broken by wind or other pressure. Occasionally the fertile fronds, too, produce buds in the axils of their divisions. The plants vary much in size, and on dry banks may be gathered down to an inch in diameter of leaf. In these small fronds the basal divisions are shorter than the others. It is known locally by the name of "Strawberry-fern."

2. *H. pinnata*, J. Smith —Stipites tufted from a small erect rootstock, 6-9 in. l. erect castaneous, glossy rusty-pubescent, rachis similar; fronds erect, 5–8 in. l. 3–5 in. w. membrano-herbaceous, densely pellucid dotted, dark green, tawny-pubescent, the terminal segment subentire lobed or pinnatifid, below this 3–5 pair of spreading distant pinnæ, the lowest pair of which are largest, and ½–¾ in. w. 2–3 in, l., the point acute or bluntish, the base free and slightly stipitate, once lobed or forked on the under side, those above simple, oblong-lanceolate, adnate at the base, the upper ones broadly so, margins subentire, or cut into broad shallow appressed lobes; veins repeatedly forked, the branches close, curved, partly free and partly anastomosing; sori thin, following the venation.

Infrequent on grassy banks near Hope and above Dublin Castle near Gordon Town; first discovered in the same district at the beginning of the century by Wiles. This has somethiug of the aspect of *Gymmogramme rufa*, which also is plentiful in the same region, but the few distant, mostly adnate, pinnæ, the lowest pair forked, pinnatifid upper part and narrow oblique areolæ of the venation are characters which at a glimpse distinguish it.

Genus XXX. Anetium, Splitg.

Sori thinly scattered on the veins, but sparingly diffused as well on the surface between, sometimes in small groups or larger amorphous patches; fronds simple; venation copiously reticulated.

A monotypic genus, with affinity to two or three generally accepted genera, but presenting in each case sufficient dissimilarity to prevent its association therewith and warrant a separate recognition. The texture, venation, habit and, to some extent, aspect show a near natural alliance with *Antrophyum*, from which the more diffused sori distinguishes it.

1. *A. citrifolium*, Splitg.—Rootstock fleshy, free-creeping, clothed with much attenuated narrow reticulated distantly toothed scales; stipites scattered, from hardly any clear to 3 in. l. or more, dark coloured; fronds entire membrano-herbaceous, densely pellucid-dotted; light green; oblong-lanceolate, pendent variable, in size, ¼ 1¼ ft. l. 1 - 3½ in. w., obtuse acute or shortly acuminate, the base gradually tapering and decurrent on the petioles; costa prominent below, but evanescent at the apex; veins reticulated, areolæ copious, very oblique; sori sparse much diffused,sporangia minute.—Pl. Fil. t. 116.

Acrostichum, Linn, Antrophyum, Fee, Hemionitis, Hooker and Baker.

Infrequent on trees in damp forests of the eastern parishes below 2,000 ft. alt. variable in size; the larger fronds occasionally 3 ft. l. and ⅓rd ft. w. and sometimes broadly furcate, or the upper part curiously cut into sharp, shortly extended lobes. While fresh the leaves are fleshy, but in drying become membranous.

GENUS XXXI, ANTROPHYUM, KAULF.

Sori in zigzag, reticulated, or straight lines, situated on the veins, oblique to or parallel with the margins and costa, superficial or sunk in shallow grooves; veins reticulated; fronds entire. A small strictly tropical genus, numbering about a score of species, which are widely diffused. About a fourth of the number are American. These have narrow linear or lanceolate leaves, of a dull cloudy colour, which grow a few together or in dense patches on trees and rocks. They are found only in very humid regions, and under prolonged drought shrivel up. The rootstocks are fleshy but slender, and the roots are densely tomentose and form a sponge-like mass very retentive of water.

Sori immersed in parallel longitudinal furrows.—1. A. lineatum.
Sori superficial in angular areolæ or zigzag lines:—
Fronds under 1 inch wide.— 2. A. lanceolatum
Fronds over 1 inch wide.— 3. A. subsessile.

1. *A. lineatum*, Kaulf —Rootstock repent short or elongated, clothed with acuminate clear reticulated scales; stipites few or several, more or less clustered, an inch or two long, or less, passing insensibly into the frond; fronds ½-1 ft. l. ¼-½ in. w. firm, densely pellucid-dotted, dull cloudy green, linear-ligulate, tapering at both ends, long acuminate, margins even; costa concealed on the upper side, but evident beneath; veins forming narrow much-elongated areolæ running parallel with the costa and margins; sori sunk in two or three equidistant parallel longitudinal grooves between the costa and margins, continuous, or only the outer ones interrupted. *Vittaria lanceolata*, Sw. *Polytænium*, Desv.

Plentiful in very damp forests in the middle and upper mountain regions, reaching 6,000 ft alt.; an abnormal species. With *Antrophyum* it agrees entirely in texture aspect and habit, but in all other characters is more allied to *Vittaria*, to which Swartz ascribed it, and from which in fact it only differs technically in the lines of sori and areolæ being multiserial.

2. *A. lanceolatum*, Kaulf.—Rootstock short-creeping, densely tomentose, clothed with small linear-acuminate dark brown, reticulated scales; fronds firm, densely pellucid-dotted, a dull cloudy green, contiguous, linear-lanceolate, long-tapering both ways, below quite to the base, of the stipites, ½-1½ ft. l. ¼-⅝ths in. w. the margins even or rather irregular, the costa strong and raised beneath at the base in the larger fronds, slender or vein-like at the apex; veins reticulated, areolæ chiefly oblong, the inner line narrow much elongated, and parallel with the costa as is also the next series, the outer ones oblique, falling short of the edge; sori linear, parallel with or oblique to the costa.

On trees, forming spreading patches, below 2,000 ft. altitude. In the narrower fronds the areolæ are only 2 serial, and run parallel with the midrib and margins; when broader the outer meshes are oblique.

3. *A. subsessile*, Kze,—Rootstock repent, short or elongated, clothed with brown reticulated even-edged scales; stipites hardly distinct, or reaching 1¼ in. l.; fronds firm, pellucid-dotted dull green above, pale beneath, erect or subpendent, subtufted, few or several, ½-1 ft. l. 1-3 in. w., oblong-lanceolate or oblanceolate, the apex acute obtuse or rounded, tapering in the lower half to the winged base; the margins thin, even or irregular; costa raised in the lower part and flat on both

sides; veins freely reticulated, falling short of the margins; areolæ copious, oblong, oblique; sori linear the lines curved, zigzag, or reticulated, quite superficial.

Infrequent on the sides of large stones and rocks in wet forests at 6,000 ft. altitude; first gathered in a disintegrated gully above the Portland road, not far from the Government Cinchona Plantations, where a good many plants then existed. It varies in size: the Jamaica-specimens are mostly small, under 6 in. l. and an inch wide, but occasionally much larger; in Guiana it is 8-12 in. l. and 2-3 in. w. It has broader fronds than any of the other species, broadest above the centre, becoming thus oblanceolate or spathulato-lanceolate, with short winged stipites.

Tribe XII Vittarieæ.

Fronds entire, rarely forked, or pinnate, linear, ligulate or ensiform, tufted or scattered; veins copiously reticulated, transversely connected, or quite free, in some cases quite absent; sori linear, costal or sub-marginal, running parallel with the margins. continuous or casually interrupted, sunk in a groove or slit or superficial; sporangia stipitate, with an incomplete vertical jointed ring, splitting transversely when mature: receptacles special or not.

This is a small tribe, which is difficult to place with satisfaction as it possesses no very obvious affinity. In some cases the sori are more or less embraced before maturity by the recurved margins of the fronds or connivent sides of the furrows, and this feature, together with the linear and transverse or longitudinal character of the sori, gives it some claim to follow *Pterideæ* and *Blechneæ*, from which however the entire absence of special involucres removes it under this arrangement. The three genera which comprise it consist of a few grass or ribbon-like fronded species, which are chiefly epiphytal on trees or rocks. They are spread through the torrid belt, quite round the world, being about equally divided between the Eastern and Western Hemispheres.

Genus XXXII. Monogramma, Schk.

Fronds small, linear, simple or forked: devoid of veins or with short simple or forked costal branches; sori linear, sunk in a longitudinal cleft down the back of the costa or superficial on both sides of it, the two lines becoming confluent laterally.

About a dozen species form this genus which in their vascular parts are among the simplest of all ferns. They are small epiphytal grass-like plants, mostly tropical in their range, through which regions they are widely but not very generally diffused. About half the number are West Indian and American. The individuals, locally, grow alone or in communities and are infrequent or rare.

Fronds with a midrib only, and no lateral veins.— 1. M. graminoides.

Fronds with simple or forked lateral veins.— 2. M. minor.
3. M. seminuda.
4. M. immersa.

1. *M. graminoides*, Baker.—Rootstock slender, cylindrical, erect, clothed with small brown scales, fronds tufted, simple, or casually forked at the top, narrowed to the base of the filiform margined stipites, 1-2 or more in. l. about $\frac{1}{2}$ li. w., herbaceo-coriaceous and stiffish, bright green, naked; midrib distinct raised on the upper side, but with no

lateral veinlets; sori oblong or linear-oblong superficial on the back or sides of the midrib, confined to the upper part of the frond, where the edges are often folded or recurved, the margin below this part flat. *M. furcata*, Desv. Hook. *Pleurogramme graminoides*, Fée. *Grammitis*, Swartz. *Cochlidium*, Klf.

On trees; apparently rare, as modern collectors have not gathered it. It was collected first by Swartz, "on trees in the highest mountains," Grisebach says, and subsequently by Wiles, both of whose specimens are in the old collections of the British Museum Herbarium. J. Smith's ferns, there also, include specimens marked from "Wiles ex herb. Lambert, 1843." A very slender species, marked by the absence of lateral veinlets, and many of the fronds being furcated.

2. *M. minor*, Jenm.—Rootstock filiform, erect minutely scaly; fronds tufted $\frac{3}{4}$-$1\frac{1}{2}$ in. l., about 1 li. w., in the broader upper part, the apex blunt, tapering gradually in the lower half or more to the base of the hardly distinct dark coloured very slender stipites, firm or coriaceous, pellucid, naked, bright green; midrib filiform, distinct flexuose, covered by the parenchyma, raised on the upper side; dark-coloured beneath toward the base; veins simple very oblique, open, not reaching the margins; sori linear or interrupted, confined to the upper half or third of the frond but not reaching the top, biserial in the groove-like depressions along, and close to, the midrib, which the lines at length quite cover, becoming confluent laterally and superficial.

Infrequent but communal on rocky banks scattered in beds of moss; gathered in the forest adjoining Murray's Flat near Mount Moses, St. Andrew at between 2,000 and 3,000 ft. altitude, It is clearly very rare, but might easily be overlooked under the conditions in which I found it. There are from six to a dozen leaves to each plant, which spread and curve upwards acquiring thereby a falcate form, giving each other plenty of room. They are broadest in the upper half or toward the top, and thence rather long-tapering to the base, the narrow wings reaching to the bottom of the slender purple stems. The venation is quite distinct and evident, though immersed.

3. *M. seminuda*, Baker.—Rootstock erect, slender, cylindrical, fibrous, the apex clothed with narrow light brown scales; stipites tufted, slender, dark coloured, 2 - 3 li. l.; fronds linear, subcoriaceous, light or brownish-green beneath, darker above, glabrous, 3 - 5 in. l. 2 li. w., the apex obtuse, the base attenuated, casually furcate, the margins thin and more or less even, midrib evident above, covered by the parenchyma; veins close, oblique, simple or forked, terminating within the margin with clavate apices; sori linear, in a groove, occupying about $\frac{2}{3}$rds of the frond, not reaching the apex or base, originating close to the midrib on each side, the two rows at length confluent and covering it, the margins of the groove sharp and sometimes replicate.—*M. graminifolia*, Hook., *Blechnum seminudum*, Willd. *Pleurogramme, linearis*, Presl. On trees growing singly in upright tufts or few plants near together. It differs from *immersa* by the much less rigid, rather broader and flatter, fronds, which are not so much thickened down the centre the sori consequently being less deeply immersed. The colour, too, is a lighter green, and brown beneath. It is many times larger than *minor*, the fronds differently shaped, and with closer, less oblique, veins.

4. *M. immersa*, Fée.—Rootstock elongated, erect, freely clothed with

brown narrow acuminate scales, the base fibrous; fronds tufted, erect or erecto-spreading, 3 - 6 in. l. $1\frac{1}{2}$ li. w., coriaceous and rigid; rather opaque, usually curved, linear, the apex blunt or acute, tapering at the base to the short and hardly distinct stipites, when fertile much thickened down to the centre and subtriquetrous, the margins even and frequently folded together, glabrous, bright grass-green, midrib distinct on the upper side, covered in the parenchyma; veins oblique, immersed, both simple and forked, not reaching the margins; sori sunk in a deep slit, down the back of the midrib, confined to the upper third half or two thirds of the frond.

Infrequent on trees on the ridges and peaks at 6,000-7,000 ft. alt. The fibrous portion of the rootstock gradually elongates in a cylindrical form to, occasionally, three or four inches in length. The slit-like groove which contains the sorus is at first closed with connivent edges, but as the fronds mature the sides of the groove open, showing the dark-brown linear sorus embraced by them. The texture is particularly rigid.

Genus XXXIII. Vittaria, Smith.

Sori linear, sunk in a marginal or intramarginal slit or groove, rarely slightly impressed or superficial, continuous and parallel with the margins; veins simple, oblique, prolonged and connected by a transverse anastomosis, which forms the receptacle; fronds entire, linear or ligulate.

A small, almost strictly tropical, genus comprising about a score of species, which are nearly equally divided between the Old and New Worlds, reaching quite round the equatorial belt and possessing considerable homogenity of form and habit, having mostly long pendent fronds, linear or strap-shaped, which grow in tufts on the branches of trees, or on rocks, in shady places or forests.

Fronds $\frac{1}{8}$ inch wide, or less.—	1. V. intramarginalis.
	2. V. lineata.
Fronds $\frac{1}{4}$–$\frac{1}{2}$ inch wide.—	3. V. stipitata.
	4. V. remota.

1. V. *intramarginalis*, Baker.—Rootstock horizontal, very shortly repent, densely clothed with hair-like reticulated serrated scales; fronds more or less tufted, few or many, the barren broader, rounded at the top, linear-spathulate, fertile linear 2-6 in. l. a line to $\frac{1}{8}$ in. w., narrowed and thickened toward the base, with no distinct unmargined petioles, tapering and acute or acuminate at the apex, back rather rounded, with a distinct narrow depression down the centre, dark green, under side much paler, the margins thin; sori sunk in continuous (or rarely, interrupted) grooves, which fall short of both apex and base of the fronds; veins distant forming long narrow costular areolæ. Journ. Bot. 1877, p. 266.

On branches of trees overhanging Ginger River, St. Mary, and near Bath, St. Thomas-in-the-East. A small plant, which much resembles seedlings of the next species, from which it is readily distinguishable by the distinct small barren fronds (not however present in full-grown plants), less coriaceous and more pliant texture, pale under surface, thin margins, and distinctly intramarginal open slits containing the sori. There is no distinct midrib, the central vein being not stronger than the lateral ones, with a line of narrow longitudinal areolæ on each side of it. The groves are medial, open and rounded, with thin edges when the fronds are dried and the surface wrinkled longitudinally.

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Deutzia Lemoinei.
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D formosum giganteum
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THE MOVEMENTS OF PLANTS.

By Professor D. T. MacDougal, M.A., M.S., Ph.D.

Lecture given at the Institute of Jamaica, June 19, 1897.

It is a matter of common custom to consider motion as a special characteristic of the animal kingdom, and when attention is called to the more apparent movements of certain well known plants, it is with the accompanying idea that it is something novel, sensational and exceptional rather than general, and that this property does not properly belong to plants.

It is pertinent to state, in the beginning of our discussion of the subject, that the power of movement is quite universally distributed among plants and that but very few species may be found which do not exhibit it in some form more or less easily observable.

Although the general purposes of the movements of plants and animals are identical, yet the general structure and mode of life of the two series of organisms is so unlike, that the greatest possible differences are to be found between the general character of the movements of plants and animals, with respect to duration, rapidity, amplitude and immediate purpose, as well as in the structure of the organs concerned in the movement, and the mechanism of the elements of which these organs are composed.

As a matter of fact the movements of animals and plants are so much unlike, that specific comparisons would be wholly unprofitable. In general however it is to be said that the power of locomotion or movement from place to place is exhibited by the greater majority of animals and by but very few plants; the movements of animals may be of great amplitude, those of plants are quite limited in range; the movements of animals may be so rapid as to elude the eye, while those of plants are generally so slow that they may be detected only by repeated and accurate measurements.

The fundamental necessity for every organism whether plant or animal is the acquisition of a proper supply of food, and a secondary necessity is the avoidance of danger, while the chief purpose of the organism is reproduction or the preservation of the species. Movement is a very important factor in the attainment of these objects, and the unlike development of this power in plants and animals is due to the widely dissimilar character and distribution of the food supply, and environmental factors encountered by the two groups.

In the consideration of this part of our subject, the time at our disposal will not permit us to pursue it to its utmost ramifications and we may direct attention to a few of the more important points only.

The animal has developed in such manner that the higher forms use substances for food, which are not uniformly distributed throughout the

soil, air and water, but occur in irregular masses. In order to acquire these separate portions of food it was and is highly necessary that the animal should be able to move from place to place, and should be able to sustain this movement sufficiently to acquire the requisite number of food-masses; hence arose the necessity for the power of locomotion, which also serves the animal as a means of protection from danger from other animals, inclemencies of the climate, etc.

The emergence of the plant from an aquatic to a terrestrial habitat in an early stage of its development was accompanied by several radical changes in its physiological organization, and from a motile, or floating body it acquired the habit of fixing itself firmly in the soil or other substatum. The power of locomotion was not only useless but impossible in its new location, and with its newly acquired rigid body, and hence it was lost.

The loss of the power of movement from place to place and the acquisition of the habit of fixation was due to the character of the food supply.

The food of plants consists of mineral salts derived chiefly from the soil and carbon dioxide from the air.

The mineral elements and water are quite widely distributed throughout the soil, and furthermore in sufficient quantity to enable a plant to meet its needs without moving from the place in which it began its existence. It is but necessary that the roots should pierce the soil and place the absorbing surfaces in contact with the solutions serving as food. The mineral food of the plant thus lies in the soil beneath it or near it laterally, and the physical conditions prevalent make something more necessary than a simple random penetration of the soil. In other words it is necessary that the root tips should be guided as they bore through the substratum. In order to guide or direct the growth of a tip of a root, it is necessary that this tip should have the power of movement or of changing the position of its axis. Thus it is of the greatest importance that the primary root of a seedling should penetrate the soil in a vertical direction and reach the moist particles at greater or less distance beneath the surface. To accomplish this the primary root should always grow downward no matter in what position it may be placed at the time of the germination of the seed. In order to do this the root has acquired the power of irritability to gravity which we term *geotropism.* A geotropic root tends to place its axis parallel to the force of gravity, that is with its point directed toward the centre of the earth. The movement by which the plant accomplishes this may be very easily demonstrated if a seedling with a root two or three inches in length is placed in such position that the root is in a horizontal position in a damp chamber. If examined an hour later it will be found that curvature has taken place in a portion near the apex and that the tip now points directly downward.

It would not suffice however for all of the root to be driven directly downward through the soil, since the soil containing the most advantageous proportions of food, lies comparatively near the surface. The lateral roots which issue from the primary roots are therefore endowed with a power of movement which tends to place their axis in a horizontal position. By a combination of the two movements it may be seen that the plant is enabled to drive its roots downward to the proper depth and laterally through the layer of the best soil. The difficulties to be overcome and the conditions to be met in this penetration of the

substratum are numerous and the root tip is most richly endowed with various forms of irritability and movement in response to such needs. Thus in finding its way, through the soil a root may encounter a stone which blocks its way or splintered fragments which might pierce and destroy the tip. The root tip is irritable to contact or injury and when it meets such objects as those named above, it bends away from them, and then once more resumes its former direction past the obstacle.

Certain portions of soil may contain more water or food material than others and it will be found that the roots curve in such manner as to direct their tips toward these portions. Then again a laterally growing root may find itself exposed to sunlight filtering down between the particles of the soil with injurious consequences. To avoid danger from this source the root has the power of bending away from the light.

The root tip responds by movement to many other forces, and it is so delicately adjusted and has acquired so many forms of irritability that Chas. Darwin compared it to the brain of an animal in his classic work "Movement in Plants."

Let us now turn our attention to some of the movements which are exhibited by the shoot and which may be seen without any troublesome detail of experimentation.

If the compound leaves of the Logwood (Haematoxylon), Shameweed (Mimosa), or Guango (Pithecolobium Saman) are examined shortly after sunrise, it will be found that the leaflets are spread open in a horizontal position, and that they are exposed to the full force of the sun's rays. (See Fig. 1.)

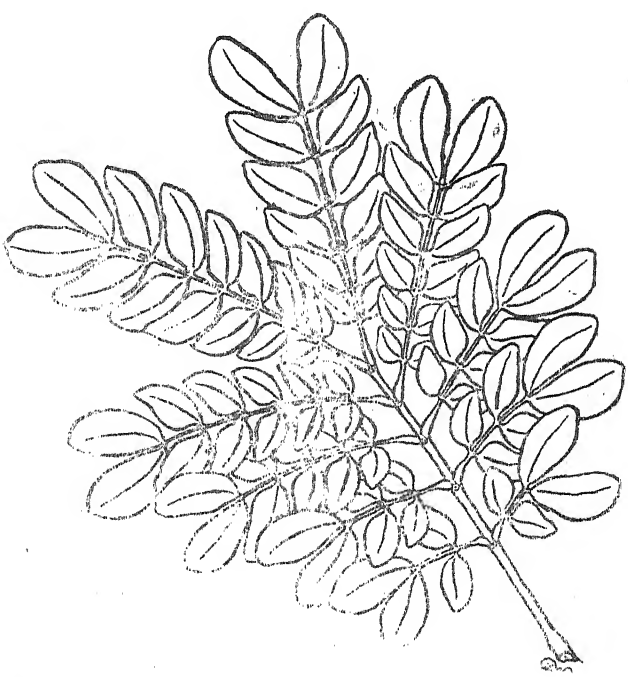

Fig. 1 Extended position of leaf of Pithecolobium Saman, Guango, occuring in the morning or in diffuse light throughout the day.

If the same leaves are examined later in the day or at a time when the sunlight is near its maximum intensity, it will be seen that the leaflets are no longer spread out to receive its full force but that they are folded together in pairs in such manner that the edges are presented to the sun, so that the rays strike the surfaces at a very acute angle, and the entire aspect of the plant is altered. (See Fig. 2.)

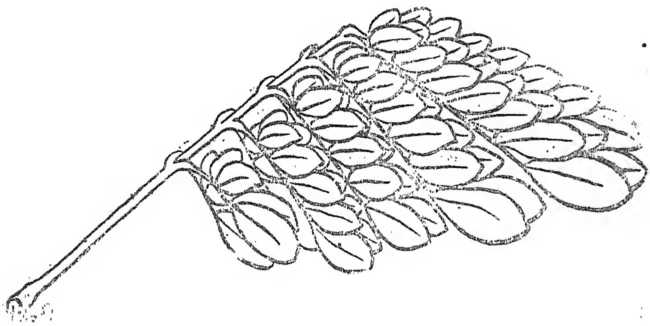

Fig. 2. Closed position of leaf of Pithecolobium Saman Guango to be seen at noon-day The position of the leaflets at night is slightly different.

The meaning of this movement may be most easily interpreted when the functions subserved by the leaves are recalled.

For the purpose of this discussion we may consider a green leaf as a mill into which water laden with mineral salts from the soil, and carbon dioxide from the air are poured, which converts these substances into sugar and other useful compounds. The driving power of this leaf-mill is sunlight, and the energy is absorbed from the light by means of the green colouring matter (chlorophyll.) Like all mills the leaf does its work best when a certain amount or intensity of force is applied to it, or in other words when it is driven at a certain rate of speed. If driven too rapidly not only is the work done less perfectly but the mechanism may suffer injury. These facts apply exactly to the leaf. It functions best when it receives light of a certain intensity.

In the plants which I have mentioned, the leaflets receive the proper amount of light for the successful performance of work when in a horizontal position, in the early part of the forenoon. As the sun advances toward the zenith, the heat and light of its rays increase in intensity, and at the same time the rays infringe at right angles on the surface of the leaves held in a horizontal position, greatly increasing their effect on the leaves. If the leaves remain exposed to the full force of the sun's rays in the morning position, the green colour will be destroyed and water will be evaporated faster than it can be brought up from the roots, and wilting or withering will ensue.

The leaflets are automatic machines however. The moment the sun beats too fiercely upon the blades, an action is set up which results in turning the edges toward the sun, and the effect of the rays is greatly lessened. In this manner the plant has almost absolute control over the amount of heat and light which may be allowed to act upon the leaves. A glance at many plants found in every door-yard will show plants which have made this adjustment to the noonday sun.

The actual value of this motion of the plant may be seen if two metal plates are exposed to the sun, one horizontally, the other vertically, in the middle of the day. A touch of the finger will reveal the difference in temperature an hour later.

As the sun sinks toward the western horizon the action of its rays decreases and the self regulating leaflets slowly open. The dangers of the day are by no means over however. As the sun disappears the air grows cooler, and the leaves radiate heat that would result in chilling and other injuries, if allowed to continue. Once more the regulating mechanism is called into play and once more the leaflets are placed in a vertical position when they radiate heat less rapidly. This so-called "sleep position" of leaves may or may not be identical with the noon-day position.

The metal plates may again be used to demonstrate the physical value of sleep movements. The plate held in a horizontal position for an hour will be found to be cooler than the one held vertically. The test is a delicate one and requires accurate thermometric measurements. The necessity for the movements of the leaflets may be shown if the leaflets of the Guango are fastened in a horizontal position and allowed to remain exposed to the full blaze of the sun and to the night air for a day or two.

All of the above movements are adaptations by which the plant facilitates the acquisition of food or protects the organs of nutrition.

It will be profitable to turn our attention for a few minutes to some specialised movements exhibited by some of the common plants of Jamaica.

The ordinary Shameweed (Mimosa) the pest of your lawns and pastures will serve as an example. The leaflets of this plant beside moving in response to changes in temperature and light, also exhibit reactions to a shock or a blow, incision or other injury, electric current, or a flame, and may be made to assume the sleep position by ether or chloroform. Although much attention has been given to this plant yet it is quite impossible to see that any useful purpose is subserved by movements in response to some of these stimuli. It is safe to say that so far as some of the stimuli are concerned, they are not met with by the plant in its original habitat in Brazil and Venezuela.

It is to be seen that the Shameweed offers several interesting features which are by no means common. Of these, one of the most striking is the manner in which impulses are transmitted from one branch to another. This may be best illustrated by reference to the diagrams. (See Figs. 3 and 4.) If the flame of a burning match is

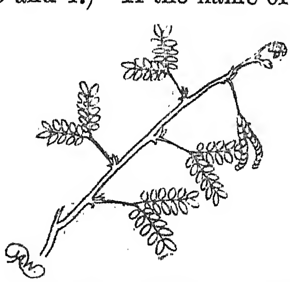

Fig. 3. Branch of Mimosa showing normal and irritated closed leaflets.

applied to the tip of a branch at A. in Fig. 4, the leaflets nearest the flame close at once by an almost instantaneous movement, then the motion is taken up by each pair of leaflets in turn until the base is reached. Then an impulse starts towards the tip of the other secondary petioles closing the leaflets in succession. Meanwhile an impulse has been travelling toward the base of the leafstalk, and as it reaches the thick cushion of tissue—the pulvinus—which joins it to the stem, the pulvinus contracts on the lower side and the entire leaf sinks downward. Impulses then travel downward and upward along the stem and branches, and out to the tips of the leaves, producing a movement similar to that of the first leaf.

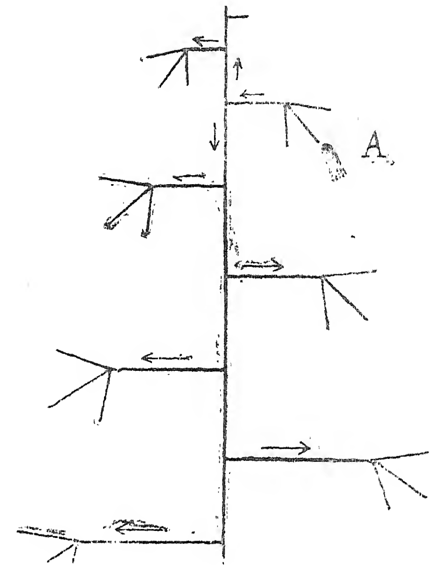

Fig. 4. Diagram showing direction of impulses in Mimosa from a flame applied at A.

It may interest you to know that the rate at which impulses travel has been accurately measured and that it is found to be about fourteen feet per minute, though dependent upon the temperature, age of the plant, etc. At the rate given, an impulse might traverse the entire body of the plant in a few seconds. All of the movements of the Mimosa are effected by means of pulvini at the bases of the primary and secondary petioles, and of the leaflets. The structure and action of a pulvinus may be illustrated by reference to the diagram. (See Fig. 5.) The portion of the stalks constituting the pulvinus consists of a central strand of very flexible hard tubes, vessels and fibres surrounded by a cylinder of thin walled cells which are capable of almost instantaneous changes in size and form. When an impulse from a shock reaches a pulvinus, the cells on the lower side at once lose a part of their con-

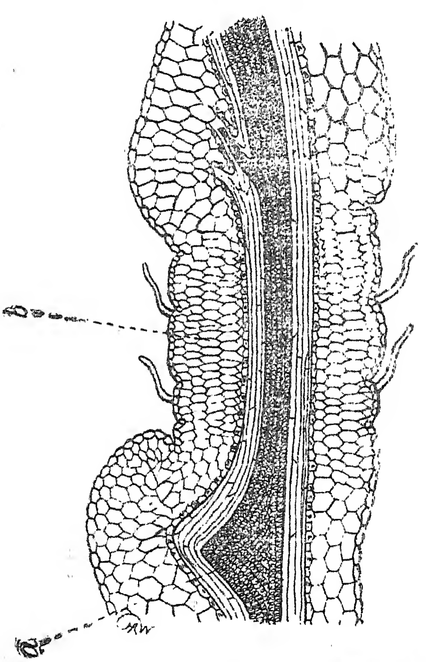

Fig. 5. Section of pulvinus of Mimosa a. Fibres and vessels. b. Upper side.

tents, which passes out into the spaces between them, and they contract with the result that the leaf stalk curves in that direction which may be upward or downward according to the location of the pulvinus. In a few minutes after a pulvinus has curved in this manner, the cells which have contracted begin to reabsorb water and finally regain their former size with the result that the leaf is in its original position in fifteen to twenty-five minutes after the stimulus was applied to the plant. It is then capable of repeating its former action.

Another movement, the object of which is unknown to us, is afforded by the "Telegraph Plant" (Desmodium gyrans) which is to be found in Jamaica. I have recently had the opportunity of examining several fine specimens in the Castleton Gardens, and am informed that it is also grown in the Hope Gardens. The general aspect of the plant is shown in Figure 6.

B

Fig. 6. Desmodium gyrans. A. Normal position of leaves. B. Leaves during darkness.

The plant belongs to the Leguminosae, and its leaves undergo the movements for adjustment to the intense sunlight and to the cool night air in the same general manner as the Guango, or the Shameweed.

If an examination of the compound leaf is made it will be found to consist of one large terminal leaflet, and one or two small lateral ones. (See Fig. 7.)

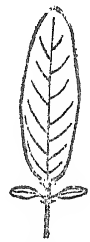

Fig. 7. Leaf of "Telegraph Plant." (Desmodium gyrans.)

The small lateral leaflets keep up a rather rapid continuous jerking movement at times when the temperature is between 72 and 104° F. The movement continues even in the night and these leaflets do not undergo "Sleep movements". The tip of the leaflets move upward and downward through an arc of one hundred and eighty degrees and at the same time twists on the stalk so that an irregular oval or ellipse is described. From two to five minutes are necessary to complete the movement.

We are not only unable to ascribe any useful purpose to this movement of the Telegraph Plant but do not understand the mechanism by which it is produced. Such marked and continuous movements are by no means common among the higher plants.

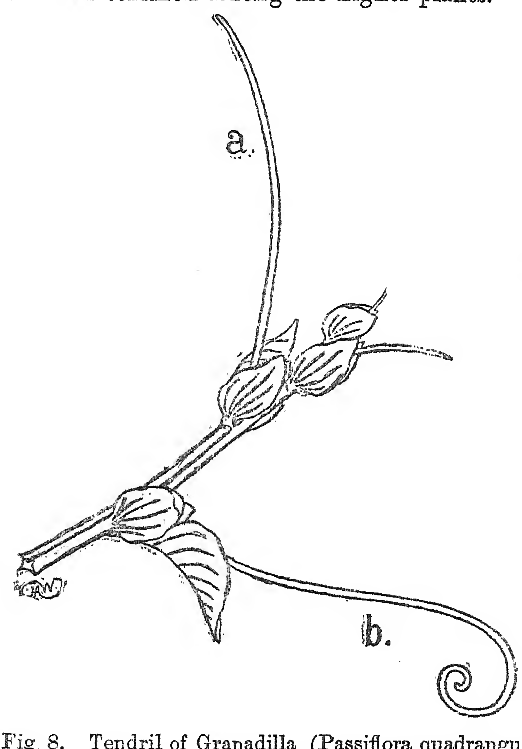

Fig. 8. Tendril of Granadilla (Passiflora quadrangularis.) a. Normal position. b curved after irritation.

It is necessary for every green plant to lift its leaves aloft into the sunlight To accomplish this more or less rigid stems and branches are constructed upon which the leaves are displayed. A comparatively enormous amount of material, energy and time are used in this process, and the plant which gets up to the sunlight without this expenditure will have a great advantage over other forms. One group of plants, the air plants (epiphytes) obtain exposure to the light by growing on the elevated branches of other plants.

Another group of particular interest in connection with this discussion, accomplish the same purpose by climbing upward over the bodies of other plants or any object near them. They may cling to the support by twining round it, or by means of special grasping organs or tendrils. The latter class is the most highly developed group since it accomplishes the climbing at the least expense.

Tendrils exhibit irritability of the most highly developed form and react to a number of stimuli by very rapid movements.

When a tendril comes into contact with a branch of a tree or another solid body, it will begin to curve in a time varying from five seconds to an hour, and soon completely encircles the body with which it has come into contact. In this manner the apical growing portions of a vine are fastened to a support. As soon as this has been accomplished the part of the tendril between the plant and the object to which it is attached exhibits another movement by which it is thrown into the form of a spiral spring, which pulls the plant upward through a distance equal to about one third the length of the tendril. The tendril will also move in response to a number of other stimuli, such as heat, acids, electric currents, and may be rendered incapable of motion by ether or chloroform.

A movement which has for its purpose the facilitation of reproduction is offered by the Water Hyacinth (Eichhornia speciosa) which is to be found in the botanic gardens of Jamaica. The perfection and germination of the seed of this aquatic plant can take place under water only. If an examination of the plant is made during the proper season it will be seen that the showy azure flowers stand upon erect flower stalks several inches above the water. Soon after the pollen has been conveyed from the stamens to the pistils the flower stalk begins to bend downward

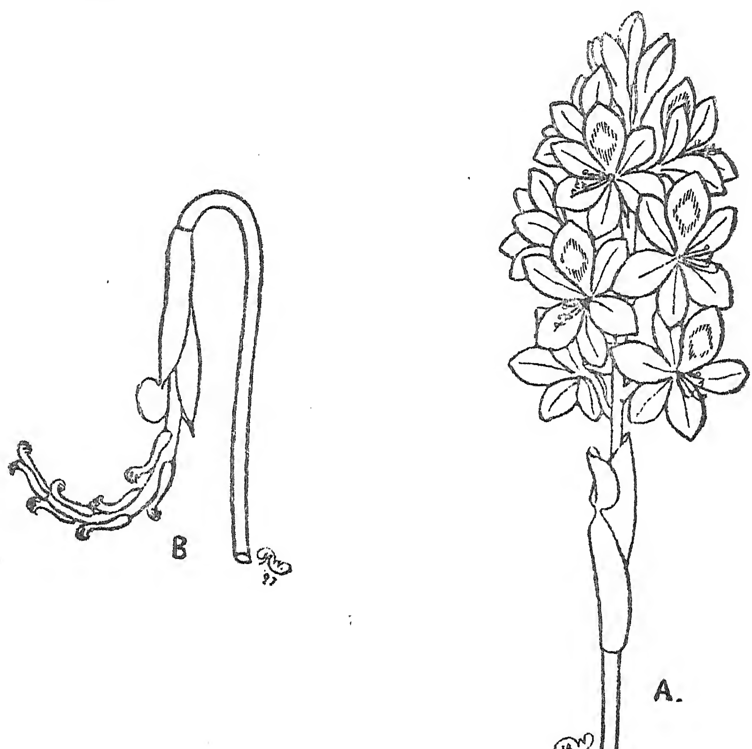

Fig. 9. Flower stalk of Water Hyacinth, (Eichhornia speciosa.) a. Normal upright position. b. Curved inverted position.

and in the course of a few hours it has moved downward through one hundred and sixty or seventy degrees and the flowers are completely immersed in water, where the development of the seed occurs. (See Fig. 9.)

The foregoing examples illustrate some of the principal or rather the more apparent forms of movement, and the time is lacking to enumerate others although of great importance and wide occurrence. It will be more profitable to spend the remaining time at our disposal in a discussion of the movements.

The external similarity of the movements of some plants to those of animals has led to many ungrounded comparisons, and to the ascription of sense or intelligence to plants. The questions at once arise in the mind of a person who observes the movements for the first time: Have plants muscles, sense-organs, and nerves, and is it conscious of the movements?

In general I may answer all of these questions by saying that the mechanism of movement of plants offers only a general analogy to that of animals, and that all motions are of a reflex character: The plant has no nervous centre, but when a stimulus acts upon any part of the plant the impulse is conveyed directly to the part of the plant producing the movement.

The plant has no structures which may be properly designated as sense organs, yet there are certain portions which alone may receive stimuli, and convert them into impulses. The extreme tip of a root, the blade of a leaf, the lower side of the tendril of the Passion Flower are specially capable of sensibility. The Shameweed is however "sensitive" over its entire surface with the exception of the flowers, seed pods and upper side of the pulvinus.

But movement is not produced at the extreme tip of a root or in the blade of the leaf, or in other words the cells which receive the stimulus, do not set up motion. The motile cells are at the base of the leaf stalk, or at some distance from the "sensitive" cells. It will be convenient to speak of the cells receiving the stimuli as constituting the "sensory" zone, and the cells producing the movement as the "motor" zone.

Now since the sensory and motor zones are separated by some distance it is evident that there must be some sort of transmission of force from one to the other. The path along which the transmission is made has not yet been made ont, that is to say the plant has no known structures analogous to the nerves of an animal.

Although the mechanism by which movement is produced in plants is not so well differentiated as that of animals, yet the degree of sensitiveness is in some instances even greater.

Thus a tendril will curve in response to a weight not appreciable to human touch and the shoot of a young plant will bend toward a light which can not be perceived by the human eye. It is of interest in this connection to note that many reputable biologists ascribe some form of consciousness to plants; the way is not clear to concur in this opinion in the present state of our information on the subject. To recapitulate the principal points in the foregoing discussion:

The power of movement is quite widely distributed among plants and is one of the most important means by which it adapts itself to its environment. The mode of life of the plant has tended to the loss of the

power of locomotion. By means of movement the absorption of food from the soil is facilitated and the roots are protected from injury. By means of movement the action of the sun upon the leaves is controlled, the food-forming processes regulated, and the leaf protected from injury from excessive light, heat, transpiration, and radiation. Movement enables the grasping organs of climbing plants to fasten to supports and pull the plant upward, and by the same property, reproduction and protection of seeds are accomplished. This summary must not be taken to cover the entire subject, but touches only upon the points included in the discussion. Movements serve many other purposes as well.

ANALYSIS OF SUGAR CANE.

By the late J. J. Bowrey, F.C.S., F.I.C., Island Chemist.*

Government Laboratory, Kingston, 18th October, 1897.

Director of Public Gardens and Plantations.

Sir,

Herewith I send two tables containing results of analysis of Canes received from the Hope Gardens in July and August last. One contains the named Canes i.e., varieties which are known in cultivation, the other numbered Canes, i.e., canes which have been raised from seed within recent years and are not yet in economic cultivation. The canes have been sampled and the analysis made in the manner described in the last Report of Agricultural Work in the Botanic Gardens, Demerara, and to facilitate comparison the results are stated as in that Report.

It is to be noted that one analysis of a variety of cane is not sufficient to determine its characteristics as to yield, strength, and purity of juice. Analysis must be made yearly for several years, before an authoritative opinion can be formed. The climatic conditions vary from year to year and greatly affect the canes and the analytical results vary much with their ripeness or otherwise.

I have carefully compared the results here tabulated with those obtained in Demerara, and it may be interesting if I now briefly state the outcome.

Named Canes.

The names Lahaina, Ko-poa-pa, China, Salangore, Grand Savanne, Po-a-ole, Hillii and Bouranappa appear in the Demerara Reports, but Queensland, Bourow, Nagapoury, Barkley and Nain do not.

I suspect however that Queensland is Queensland Creole, Bourow is Boisrouge, and possibly Nagapoury is Naga or Keeming, and Nain is Mani. The other canes appear in the Demerara Reports under the following synonyms:

Otaheite	syn	Bourbon
Elephant	"	Jamaica Transparent.
Caledonian Queen	"	White Elephant.
Java	"	
Hope	"	
Red Rose Ribbon	"	Red Ribbon.
Green Rose Ribbon	"	Green Ribbon.
Brisbane	"	

* We record with sincere regret the death of Mr. Bowrey on 19th November, while this article was passing through the press. [Ed.]

Comparison of canes grown in Jamaica with the same varieties grown in Demerara.

WEIGHT OF CROP PER ACRE.

Rather smaller,	... Elephant.
About equal,	... Otaheite, Caledonian Queen, Java, Hope, Red Rose Ribbon and Hillii.
About double,	... Salangore, Green Rose Ribbon and Brisbane.
About three times,	... China and Po-a-ole.
About five times,	... Ko-poa-pa.

PROPORTION OF JUICE.

Is about equal or slightly larger than that yielded by the same variety in Demerara.

PROPORTION OF SUCROSE IN THE JUICE.

Less	... Lahaina, Ko-poa-pa, Elephant, Green Rose Ribbon, Brisbane and Po-a-ole, (Second Ratoons.)
Equal	... Po-a-ole, (Plant Canes.)
Greater	... Otaheite, China, Salangore, Caledonian Queen, Java, Hope, Red Rose Ribbon. Green Rose Ribbon, Brisbane, Grand Savanne, Hillii, Bouranappa.

QUOTIENT OF PURITY.

Follows much the same order as the proportion of Sucrose.

YIELD OF SUGAR PER ACRE SUPPOSING 85 PER CENT. OF THE SUCROSE IN THE JUICE IS WON.

This is smaller from the Elephant Canes but larger from all the others as might be expected from the superiority in weight of crop per acre.

I suspect that the six canes which proved inferior in proportion of sucrose and purity were not really ripe.

NUMBERED CANES.

These Canes compare more irregularly than do the named canes, as will be seen from a glance at the table appended.

On this table I would remark that Nos. 95 and 119 are very little below the Demerara grown canes of the same numbers, in contents of sucrose; while I suspect that the other canes which yielded less sucrose were not fully ripe.

In conclusion I would repeat that one year's results are not sufficient to allow a decided opinion to be formed and that these experiments need to be repeated before it will be possible to determine the fitness or otherwise of these canes for cultivation in Jamaica.

I am, Sir,
Your Obedient Servant,

J. J. BOWREY,
Island Chemist.

Numbered Canes grown in Jamaica compared with the same varieties grown in Demerara.

Weight of Crop per Acre.			Proportion of Sucrose in Juice.			Quotient of Purity.			Sugar per Acre supposing 85 p.c. iron.		
Less.	Equal.	Greater.	Less.	Equal.	Grea te.	Less.	Equal.	Greater.	Less.	Equal.	Greater.
–	–	32	–	32	–	–	32	–	–	–	32
–	–	49	49	–	–	49	–	–	–	49	–
–	–	51	-	–	51	–	–	51	–	–	51
–	53	–	–	53	–	–	53	–	–	53	–
–	61	–	61	–	–	61	–	–	61	–	–
–	–	74	74	–	–	74	–	–	–	74	–
–	78	–	78	–	–	78	–	–	78	–	–
–	–	81	81	–	–	81	–	–	–	–	81
–	–	95	95	–	–	–	95	–	–	–	95
–	–	99	–	99	–	–	–	99	–	–	99
–	–	108	–	108	–	108	–	–	–	–	108
–	–	109	–	–	109	–	–	109	–	–	109
115	–	–	–	–	115	–	–	115	–	115	–
–	–	117	–	117	–	–	–	117	–	–	117
–	–	119	119	–	–	119	–	–	–	–	119
–	128	–	–	–	128	–	128	–	–	128	–
–	–	145	145	–	–	145	–	–	.	–	145
–	–	212	–	–	212	–	–	212	–	–	212
–	–	246	–	246	–	–	246	–	–	–	246

Named Canes.

Name of Cane.	No. of Canes Per Acre.	No. of Canes Per Stool.	Weight of Canes per acre in tons.	Average weight in Lbs. Canes.	Average weight in Lbs. Stool of Canes.	Percentage of Juice.	Specific Gravity.	Gallons of Juice per Acre.	Lbs. per Gallon of Sucrose.	Lbs. per Gallon of Glucose.	Lbs. per Gallon of Solids not Sugar.	Quotient of Purity.	Lbs. of Sugar per Acre.	Equal to Tons of 1st and 2nd Sugar per Acre.
Otaheite	20,872	11.5	41. 93	4.5	51.7	65. 7	1. 084	5,692	2.006	.034	.147	91.7	11,418	4. 33
Lahaina	17,424	9.6	42. 78	5.5	52.8	73.10	1. 067	6,565	1.365	.244	.146	77.8	8,961	3 40
Ko-poa-pa	23,232	12.8	54. 96	5.3	67.8	71. 8	1. 069	8,268	1.427	.217	.164	78 9	11,798	4. 48
Elephant	8,167	4 5	13.125	3.6	16.2	70. 5	1. 069	1,939	1.407	.270	.121	78.2	2,728	1.035
China	18,150	10.0	55. 10	6.8	68 0	71. 5	1 076	8,201	1.719	.172	.082	87.1	14,097	5. 34
Salangore	27,225	15.0	40. 10	3.3	49.5	71. 4	1. 086	5,905	2.016	.133	.084	90.2	11,903	4. 51
Caledonian Queen	20,146	11.1	32. 37	3.6	39.9	64. 9	1. 089	4,315	2.188	.034	.094	94.4	9,441	3. 58
Java	27,225	15.0	54. 69	4.5	67.5	68. 6	1. 082	7,7·6	1.997	.072	.082	92 8	15,508	5. 88
Hope	24,684	13.6	47. 38	4.3	57.4	66. 9	1.0834	6,553	1.980	080	.108	91.3	12,974	4. 92
Red Rose Ribbon	20,872	11.5	37. 27	4.0	46.0	67. 3	1. 089	5,159	2.188	.025	.094	94.8	11,287	4. 28
Green Rose Ribbon	27,225	15 0	66. 84	5.5	82.5	78. 4	1. 062	11,053	1 078	.377	.153	67.0	11,915	4. 52
Green Rose Ribbon	27,225	15.0	66. 84	5 5	82.5	74. 0	1. 067	10,834	1.349	.270	.132	77.0	14,615	5. 54
Brisbane	34,485	19.0	70. 81	4.6	87.4	74. 5	1 074	11,002	1.526	.298	.112	78.8	16,789	6. 37
Grand Savanna	31,399	17.3	63. 07	4.5	77.8	70. 7	1. 090	9,163	2.120	.138	.092	90.2	19,425	7. 37
Po-a-ole	61,710	34.0	137. 74	5.0	170.0	70. 6	1. 070	20,352	1.459	.213	.137	80.6	29,693	11. 2
Po-a-ole 2nd R.	58,080	32.0	106. 30	4.1	131.2	76. 2	1. 055	17,198	.948	.312	.173	66.1	16,303	6. 18
Hillii	33,577	18.5	44. 96	3.0	55.5	65. 2	1 088	6,035	2 110	.126	.060	91.8	12,733	4. 83
Queensland	19,602	10.8	22. 75	2.6	28.0	65. 2	1. 087	3,056	2.047	.076	.149	90.1	6,255	2. 37
Bourow	16,879	9.3	39. 93	5.3	49.2	72. 2	1. 076	6,001	1.750	.189	.046	88.1	10,501	3. 98
Bouranappa	29,584	16.3	54. 14	4.1	66.8	72. 3	1. 087	8,066	1.980	.192	.083	87.8	15,970	6. 06
Nagapoury	24,139	13.3	58. 88	5.0	66 5	67. 5	1. 080	7,543	1.704	.213	.139	82.8	12,853	4. 87
Nain	31,944	17.6	51. 33	3.6	55.4	71. 5	1. 083	7,591	1.787	.200	.164	83.07	13,565	5. 14
Barkley	23,595	13.0	31. 60	3.0	39.0	66. 6	1. 088	4,332	2.120	.050	.109	93.0	9,183	3. 48

These are Plant Canes excepting [illegible] R. which was second ratoon.

Numbered Canes.

Number of Canes.	No. of Canes. Per Acre.	No. of Canes. Per Stool.	Weight of Canes per acre in Tons.	Average weight in Lbs. Cane.	Average weight in Lbs. Stool of Canes.	Percentage of Juice.	Specific Gravity.	Gallons of Juice per Acre.	Lbs per Gallon of Sucrose.	Lbs per Gallon of Glucose.	Lbs per Gallon of Solids not Sugar.	Quotient of Purity.	Lbs of Sugar per Acre.	Equal to Tons of 1st and 2nd Sugar per Acre.
32	29,040	16.	58.33	4.5lbs.	72.0lbs	67.6	1.079	8,186	1.557	312	.185	75.8	12,745	4 83
49	22,324	12.3	30.89	3.1 "	38.1 "	69.6	1.068	4,509	1 266	.323	.186	71.3	5,708	2 16
51	21,417	11.8	36.33	3.8 "	44.4 "	61.7	1.078	4,657	1.823	.031	.188	89.2	8,489	3.22
53	22,869	12.6	30.62	3.0 "	37.8 "	68.7	1.075	4,383	1.667	111	.176	85.2	7,306	2.77
61	22,869	12.6	33.69	3.3 "	41.5 "	72.0	1.076	5,049	1.511	.250	228	76 0	7,629	2.89
74	31,399	17.3	50.46	3 6 "	62.1 "	71.2	1.077	7,472	1.584	.186	.223	79.5	11,835	4.49
78	26,862	14.8	45.56	3.8 "	56.2 "	67.9	1.071	6,470	1.474	.137	.224	80.3	9,536	3.61
81	34,485	19.0	70.81	4.6 "	87.4 "	74.4	1.063	11,101	1.146	.333	.161	69.8	12,721	4 82
95	24,684	13.6	45.18	4.1 "	55.7 "	70.3	1.083	6,569	1 980	.068	.120	91.3	13,006	4 93
99	36,300	20.0	81.02	5.0 "	100.0 "	67.5	1.086	11,280	2.068	.094	.081	92 2	23,327	8 85
108	24,502	13.5	32.81	3.0 "	40.5 "	64.1	1.084	4,346	1.891	.197	.096	86·6	8,218	3.11
109	27,225	15.0	52.26	4.3 "	64.5 "	64.1	1.084	6,9 2	1.948	.108	.131	89.1	13,484	5.11
115	19,057	10.5	34.88	4.1 "	43.0 "	66 8	1.083	4,819	1.969	058	.145	90.6	9,488	3.60
117	28,132	15.5	51.49	4.1 "	63.5 "	66.8	1.085	7,101	2.006	089	.123	90.4	14,244	5 40
119	19,965	11.0	40.10	4.5 "	49.5 "	72.4	1.069	6,083	1 438	.179	175	80.2	8,747	3.31
128	20,146	11.1	34.17	3.8 "	42.1 "	66.6	1.077	4,733	1.631	.238	138	81.3	7,719	2.92
145	21,054	11.6	57.33	6.1 "	70.7 "	75.7	1.065	9,128	1.177	.385	.132	69.5	10,743	4.07
145	21,054	11.6	57.33	6.1 "	70.7 "	73.3	1.067	8,822	1.167	.415	142	67.7	10,295	3.90
212	16,335	9.0	43.75	6 0 "	54 0 "	69.5	1.086	6,271	2.000	128	114	89.2	12,542	4.75
212	16,335	9.0	43.75	6.0 "	54.0 "	69.3	1.082	6,276	1.957	.081	098	91.6	12,282	4.66
246	20,872	11 5	55.90	6.0 "	69.0 "	66.3	1.078	7,701	1.802	.065	.151	89.3	13,877	5 26

All these Canes were Plant Canes.

ELEMENTARY NOTES ON JAMAICA PLANTS.

1. Limnanthemum Humboldtianum, Griseb.

Humboldt's Pond Flower.

This beautiful little aquatic, at the first glimpse we get of it in ponds, looks like a minature Water Lily with its white flowers and floating leaves.

An examination however of the structure of the flower will show how very different it is from the true Water Lilies,—Nymphæa and Nelumbium.

A Nymphæa has numerous petals all separate from one another, whereas this plant, as may be seen in figures b & e, has its petals united to one another.

We may give it an English name, and call it "Pond Flower," which is the meaning of Linnanthemum, or "Humboldt's Pond Flower" which connects its geographical extension from Mexico to South Brazil and the West Indies with the name of the great traveller through these lands.

It is beautifully adapted to its aquatic life. The leaf shoot springs from under water, at first with the edges of the leaf rolled up tight, so that there is no resistance as it gradually rises out of the water. Then the leaf unrolls, and sinks on the surface a floating leaf, supporting the plant, and providing for the opening of the flower above the water where moths or other insects can visit and fertilise it.

The flowers spring several together from a point on the shoot just below the blade of the leaf. If the drawings b & e are compared, it will be seen that some flowers have a long pistil and short stamens, whilst others have a short pistil and long stamens. This arragement is for the purpose of ensuring cross-fertilisation, which is so much more advantageous to the species than self-fertilisation in securing better seeds. A moth visiting the flower for the purpose of sucking the honey secreted by a small gland at the base of the petal (fig. e), puts its long tongue between the pistil and the petal. If the flower has a short pistil, the stamens are high up above it, and the insect's tongue touching them is dusted with pollen. When it goes to a flower with short stamens, the place on its tongue covered with pollen reaches the stigma of the pistil, and fertilises the flower with pollen from the other flower, at the same time carrying off pollen for a flower with long stamens.

When the flower is fertilised, it gradually bends over, as shown in the figure, sinks below the surface of the water, and ripens its seed there in seclusion to drop into the mud below.

There are certain features in the structure of the flowers which show a family resemblance to other plants, and all these plants are accordingly classed together as a natural family, or order, called Gentianeæ from the gentians which are so abundant on the Alps of Switzerland. These family features should be carerully observed in all the plants of the order that can be found, and the differences amongst the family groups, or genera, also noted.

The commonest plants belonging to this order in Jamaica are species of Leianthus, which have flowers looking very much like yellow Fuchsias. One species *Leianthus umbellatus,* forms a small handsome tree, a most unusual form, as the Gentian order is almost universally

JAM. 10. 1.

Limnanthemum Humboldtianum, Griseb.

E. A. Wood, del.

composed of quite low-growing plants. MACROCARPÆA differs in having a two-lipped stigma. The only other yellow flowered member of this order occurs in VOYRIA, a very peculiar genus, without any green colouring, and only minute scale-like leaves; the plants live on decaying leaves and do not elaborate their food themselves from air and soil. Another species of Voyria has a red flower.

The species of SCHULTESIA have red or purplish flowers with a square stem and 4-winged calyx. ERYTHRÆA has red flowers with spirally-twisted authers. EUSTOMA has blue or white-variegated flowers; it grows on dry banks on the sea-shore. LIMNANTHEMUM is aquatic.

Nearly all the plants of this order contain a bitter principle, which possesses tonic properties.

Eustoma, the "Gentian Centaury" is a tonic and febrifuge. A tea can be made of three drams of the whole plant in a pint of water, and may be used instead of quinine. Descourtilz recommends its use in Yellow Fever. He says:—"L'infusion vineuse se prépare en mettant digérer à froid quatre gros de la tige dans deux pintes de vin de Bordeaux blanc. J'ai obtenu de très grands succès d'une cuillerée de ce vin, édulcoré avec le sirop d'éther, dans les syncopes qui accompagnent la fièvre jaune."

Schultesia is said by Descourtilz to be stomachic, febrifuge, emmenagogue, anthelmintic and alexipharmic. He recommends its use in intermittent fevers, but particularly in chronic diarrhœa.

Linnanthemum, the Pond Flower, is not only a tonic and febrifuge, but is also anti-scorbutic.

The following are the general characters of the order:—

GENTIANEAE.

Flowers regular.

Sepals, generally 5 or 4, distinct, inferior.

Petals 5 or 4 connate, hypogynous.

Stamens as many as petals, alternate with them, inserted on corolla-tube.

Carpels 2, connate into a 1-celled or more or less completely 2-celled superior ovary; placentas parietal; ovules many, horizontal.

Capsule opening along the margins of the carpels.

Seeds small albuminous.

Herbs, shrubs or small trees, with bitter juice.

Leaves opposite (but one only in Limnanthemum), entire, without stipules.

To put it rather more briefly: amongst Gamopetalæ with superior ovary of two carpels, Gentianeæ may be distinguished as having a regular corolla, stamens as many as the corolla-lobes and alternate with them, ovary one-celled, juice bitter.

The characters of the genera and species may be shortly indicated as follows:—

LEIANTHUS.

Calyx 5 cleft. Corolla, narrowly funnel-shaped, 5-lobed, yellow, persistent Ovary with the placentas sometimes so far intruding as to make it appear to be 2-celled. Stigma one, round. Herbs, shrubs or small trees.

* Inflorescence a long-stalked umbel, surrounded by small leaves.

1. *L. umbellatus*, Griseb. A shrub or small tree.

** Inflorescence paniculate.

2. *L. exsertus*, Griseb. Stamens 2 or 3 times as long as corolla. 6 to 12 feet high.

3. *L. latifolius*, Griseb. Stamens not longer than corolla. Leaves 3 to 6 inches long, with long petioles. 4 to 6 feet high.

4. *L. longifolius*, Griseb. Stamens not longer than corolla. Leaves 1 to 3 inches long, with very short petioles. 1 to 3 feet high.

VOYRIA.

Calyx 5-lobed. Corolla salver-shaped, 5-lobed. Stigma capitate. Herbs without green colouring-matter, growing on decaying leaves or wood. Leaves reduced to scales.

* Stem simple, one-flowered.

1. *V. uniflora*, Lam. 6 to 8 inches high. Corolla yellow, one inch long.
2. *V. tenella*, Guild. 1 to 4 inches high. Corolla red, $\frac{1}{3}$ to $\frac{1}{2}$ inch long.

** Inflorescence with more than one flower.

3. *V. mexicana*, Griseb. 4 to 6 inches high. Corolla $\frac{1}{4}$ to $\frac{1}{3}$ inch long.

ERYTHRÆA.

Calyx 5-cleft. Corolla salver-shaped, 5-lobed. Anthers when burst becoming spiral. Stigmas two. Annual herbs.

E. ramosissima, Pers. "Centaury." Corolla red.

SCHULTESIA.

Calyx 4-keeled, 4-lobed. Corolla funnel-shaped, 4-lobed. Stigmas 2, broad Annual herbs.

1. *S. stenophylla*, Mart. Inflorescence forked, with many flowers, corolla red-violet $\frac{3}{4}$ in long.
2. *S. heterophylla*, Miq. Flowers one or a few. Corolla red, $1\frac{1}{2}$ inch long.

EUSTOMA.

Calyx 5-cleft, keeled. Corolla bell-shaped, 5-cleft. Anthers when burst, curved back. Ovary 1-celled with the placentas growing in; stigmas 2, broad. Glaucous herbs.

E. exaltatum, Griseb. "Gentian Centaury." Corolla blue, 1 inch long.

MACROCARPÆA.

Calyx 5-lobed, not keeled. Corolla funnel-shaped, 5-lobed, deciduous. Anthers when burst, curved back. Ovary with the false appearance of being 2-celled from the intrusion of the placentas which meet and divide at the centre; stigmas 2. Shrubs.

1. *M. thamnoides*, Gilg. Corolla greenish-yellow, 1 inch long. Stamens exserted. Leaves elliptical.
2. *M. Hartii*, Kr. & Urb. Corolla yellowish, 1 inch long. Stamens equalling corolla-tube. Leaves obovate.

LIMNANTHEMUM.

Calyx 5-cleft. Corolla almost rotate, 5-cleft. Capsule not opening regularly. Aquatic herbs.

L. Humboldtianum, Griseb. Corolla white. Leaves cordate-roundish.

CABINET WOODS: MARKET REPORT.

As information is occasionally sought from the Department on the market prices of some of the Jamaica Cabinet Woods, it may be of interest to have the opportunity of seeing the following Report, for which we are indebted to Messrs. Park Macfadyen, & Co., of 25 Lime St., London, E.C. The Report is given in full, so that comparison may be made with exports from other places.

MARKET REPORT ON MAHOGANY, CEDAR, WALNUT WOOD, ROSEWOOD, AND OTHER CABINET WOODS, &c.

(*From 6th to 20th September, 1897.*)

29 Clements Lane,
London, E.C., 20th September, 1897.

MAHOGANY.—Arrivals have been very light, and, as important sales have been effected, stocks in first hands are now in small limits. Prices for good wood keep steady, and a large quantity of an inferior character has been cleared without further weakness, so that the general tone is healthy. HONDURAS.—The wood offered last week all sold readily and well, as the demand is good, and supplies of this description were needed. NICARAGUA—is in fair demand. COLUMBIA.—Fresh arrivals of sound, sizable wood should sell satisfactorily. TABASCO.—Logs of good sizes, and in fair condition, sell well, and stocks are now unusually low. MINATITLAN.—Sizable, sound logs would bring fair prices, but unsold stock is limited to small wood. TECOLUTLA.—Considering its very inferior condition, the wood sold last week brought good prices; the market is now cleared, and fresh cargoes of sizeable, sound logs would be well received. PANAMA.—Good wood, of fair sizes, would sell readily, but faulty and badly-split logs are not wanted. AFRICAN.—Large sales have been effected without change in prices. Small and poor wood has been shipped too freely, but there has been no excess in the supply of good logs from medium to large sizes. ST. DOMINGO.—There is no stock, and good cargoes would sell well. CURLS — Only prime pieces are wanted. CUBA—continues to sell readily, and commands full prices, supplies being unequal to the demand.

CEDAR.—CUBA, HONDURAS and MEXICAN.—Sizeable wood, sound and straight, sells fairly well, but for small logs, the tendency is still weak. PARAGUAY—is passing into consumption very slowly, and stocks are heavy. PUNTA ARENAS, PANAMA, AFRICAN, TRINIDAD, etc.—Small and poor logs, of which late imports have chiefly consisted, can only be placed at low prices. AUSTRALIAN.—Only sound, well-squared logs of good sizes should be shipped. PENCIL CEDAR—if large and sound, would bring fair prices.

WALNUT WOOD.—AMERICAN BLACK.—*Logs*—continue dull; stocks are not increasing, but consumption is inactive, and only really good wood should be shipped; *planks* and *boards*—are in fair demand, but prices are low, except for medium to prime grades, which keep good. ITALIAN— is in very limited demand, and there is sufficient stock. BLACK SEA.—The only enquiry is for large, prime logs. BURRS.—Finely figured pieces would realise good prices.

ROSEWOOD.—RIO and BAHIA.—Prices are stationary, the demand showing no signs of improvement. EAST INDIA—is wanted, and good parcels would find ready buyers. MADAGASCAR.—Large wood, of good colour, would realise fair prices.

SEQUOIA (CALIFORNIAN REDWOOD).—There is a moderate demand without variation in prices.

AMERICAN WHITEWOOD.—*Logs*—continue of slow sale without any advance in prices; *planks* and *boards* —are quiet and prices rather weak as stocks are large.

KAURI PINE.—For *logs* there is a small demand, but a good inquiry for *planks* and *boards*.

SATIN WOOD.—Porto Rico. St. Domingo, St. Lucia and Cuba.—Sales have been small as the demand has fallen off and lower prices have to be accepted. Bahamas and Jamaica—are seldom asked for. East India.—The stock is too heavy for present demand.

LIGNUM VITÆ.—St. Domingo —has not been imported for a long time and really good parcels would sell well as supplies are much needed. Bahamas—is more asked for. Jamaica, Puerto Cabello, Curaçoa and Cuba.—Only well-grown wood, of good sizes, should be shipped, as there is a large stock of badly grown and small-sized pieces, which are very unsaleable.

EBONY.—Ceylon.—There is very little stock, but scarcely any demand. East India—if really good would find buyers at fair prices. Madagascar, Mauritius and Macassar.—Large, sound wood, of good colour, would realise fair prices.

COCUS WOOD—is in moderate demand.

BOXWOOD.—Persian and Arabian—are in good demand at steady rates. African—would find buyers at fair prices.

SNAKEWOOD.—There is no stock, but very little enquiry.

LANCEWOOD SPARS.—Shipments have moderated, but still sales are not easily effected and prices keep very low. Degame Spars—are asked for and would sell well.

LOGWOOD—is in moderate demand at recent rates.

FUSTIC—is quiet, but steady.

The Arrivals during the past fortnight have been:—

HONDURAS.

"Spheroid" at Belize to Messrs. Gonzalez, Byass, & Co., Ltd.
281 logs Mahogany. 3 logs Cedar.
Ditto at do. to Messrs. P. Leckie & Co.
400 logs Mahogany. —
Ditto at do. to J. E. Plummer Esq.
160 logs Mahogany. 58 logs Cedar.
Ditto at do. to The Belize Estate & Produce Co. Ltd.
615 logs Mahogany. —
"Barbadian" at Puerto Barrios to Order (via Liverpool) 282 logs Mahogany. —

CUBA.

"La Fayette" at Havanna to Order
47 logs Mahogany. —

Also—Mahogany, 265 logs African viâ Liverpool, &c.; Walnut Wood, American Black, 45 logs at Baltimore; American Whitewood, 14 logs, at Philadelphia; Satinwood, 24 logs East India at Colombo; Ebony 817 pieces at Mauritius; Lancewood Spars, 362 pieces at Jamaica, 260 pieces Cuba at Havanna.

The sales reported have been:—

HONDURAS.

"Sibun" at Belize Mahogany 580 logs at from 3¼d. 9¼d., average 4⅞d. per ft. fully (part cargo)
Do. at Belize Cedar 11 logs at from 4⅝d. to 8¼d., 5⅞d. average per ft. barely.

TABASCO.

"Excelsior" at Laguana MAHOGANY 194 logs at from 4d. to 9½d. 5$\frac{1}{16}$d. per ft.
(one lot at 3½d.)
Do. at Laguana CEDAR 34 logs at from 5d. to 5½d., average 5$\frac{3}{32}$d. per ft. fully.
"Carl" at Laguana MAHOGANY 98 logs at from 3¼d. to 6½d., average 4$\frac{3}{16}$d. per ft.

MEXICAN.

"Sichem" at Tecolutla MAHOGANY 345 logs at from 2¼d. to 4½d., average 2$\frac{13}{16}$d. per ft. fully.
(balance cargo) (one lot at 2d.)
"Edwin Bailey" at Tlacotalpam MAHOGANY 5 logs at 3¼d. per foot.
Do. at do. CEDAR 37 logs at 3¼d.
Do. at do. CEDAR 45 logs upon private terms.
"Susanne" at Tecolutla MAHOGANY 346 logs upon private terms.

AFRICAN.

"Batanga," &c. at West Coast of Africa MAHOGANY 127 logs at from 2d. to 10d. average 3$\frac{7}{32}$d per ft. barely.
"Biafra," &c. at West Coast of Africa MAHOGANY 540 logs at from 2d. to 13½d. average 3$\frac{3}{8}$d. per ft.
Do. at do. CEDAR 3 logs at 3¼d. & 3½d., average 3$\frac{11}{32}$d. per foot.

CUBA.

"A Keene" at Cuba MAHOGANY 386 logs at from 4¾d. to 15d., average 6$\frac{3}{16}$d. per foot fully.
(balance cargo)
Do. at Cuba CEDAR 1 at 4¼d. per foot.
"Lafayette" at Cuba CEDAR 47 logs at from 4¾d. to 8½d., averago 5$\frac{5}{8}$d. per ft. fully
"Washington" at Havanna CEDAR 67 at from 4¾d. to 5½d. average 5⅛d. per foot. barely.

Also—MAHOGANY, 11 logs COLUMBIA, 46 logs PANAMA, upon private terms; CEDAR, 42 logs TRINIDAD @ 3d. per foot, 108 logs TRINIDAD, and 6 logs WEST INDIA, upon private terms; WALNUT WOOD, AMERICAN BLACK, 20,415 planks and boards; 56 planks ITALIAN; AMERICAN WHITEWOOD, 1 log; KAURI PINE, 62 planks, all upon private terms; SATINWOOD, 23 logs and 10 planks CUBA at from 5d. to 1s. 9d. per foot, 25 logs WEST INDIA; at from 4d. to 1s. per foot; St. DOMINGO, 6 logs at 9d. per foot, and 15 logs upon private terms; COCUS WOOD, 452 pieces (13 tons) JAMAICA; LANCEWOOD SPARS, 260 pieces CUBA, all upon private terms.

PRICES CURRENT.

CARGO AVERAGE.

MAHOGANY, per foot superficial				
Honduras	...	4½d.	to	6d.
Tabasco	...	4d.	"	6½d.
Mexican	...	3½d.	"	4½d.
Panama	...	3d.	"	4½d.
African	...	3d.	"	5d.
Cuba	...	5d.	"	6½d.
St. Domingo	...	4¾d.	"	6½d.
" Curls, good to prime	...	9d.	"	15d.
CEDAR,				
Cuba	...	4d.	"	4½d.
Hondu[illegible] &c.	...	3d.	"	4½d.

Paraguay	...	3d.	"	3¼d.
Australian	...	3d.	"	4½d.
Punta Arenas, Panama, &c.	...	3d.	"	4d.
Pencil, per foot cube	...	2s. 6d.	"	3s. 9d.
WALNUT WOOD,				
Italian, per foot super	...	3d.	"	7d.
Black Sea, per ton	...	£6	"	£12
American, per foot cube	...	2s. 3d.	"	4s. 6d.
" " (plank and boards)	...	2s.	"	6s.
SATIN WALNUT, (logs) (nominal)	...	1s. 3d.	"	1s. 9d.
" (planks and boards)	...	2s.	"	2s. 9d.
SEQUOIA (Californian Redwood), per foot cube	...	1s. 8d.	"	1s. 10d.
WHITEWOOD,				
American..................(logs)	...	1s. 3d.	"	1s. 6d.
" ....(planks and boards)	...	1s. 6d.	"	2s. 9d.
KAURI PINE...............(logs)	...	1s. 9d.	"	2s.
" ....(planks)	...	2s. 3d.	"	2s. 9d.
MAPLE, per foot super............prime	...	6d.	"	8d.
SATIN WOOD.				
Porto Rico	...	6d.	"	18d.
St. Domingo	...	5d.	"	12d.
East India	...	5d.	"	12d.
Bahama. per ton	...	£3 10s.	"	£5
Jamaica "	...	£4	"	£6
ROSEWOOD, per ton				
Rio	...	£7	"	£14
Bahia	...	£6	"	£12
Madagascar	...	£4	"	£6
East India	...	£8	"	£10
TULIP WOOD..............(nominal)	...	£5	"	£8
LIGNUM VITÆ,				
City St. Domingo............(prime)	...	£8	"	£12
" " ....ordinary to fair	...	£4	"	£7
Bahama	...	£4	"	£6
Jamaica	...	£3	"	£5
Cuba	...	£6	"	£10
EBONY,				
Ceylon	...	£6	"	£12
East India	...	£7	"	£8
Mauritius	...	£6	"	£10
Madagascar	...	£7	"	£9
COCUS WOOD...........ordinary to fair	...	£3 10s.	"	£4 10s
" ....large and good	...	£5	"	£7
BOXWOOD,				
Turkey and Persian......ordinary to fair	...	£4	"	£8
" ....good to prime	...	£9	"	£15
African	...	£4 10s.	"	£5 10s
SNAKEWOOD	...	£8	"	£10
LANCEWOOD Spars, each, fresh and large	...	4s.	"	7s.
" ordinary to fair	...	2s. 6d.	"	3s. 6d.
DEGAME Spars	...	10s.	"	15s.

LONDON & INDIA DOCKS STOCK ACCOUNT.

		Landings | Deliveries during the past fortnight.		Landed Stock, 20th Sept., 1897.	Landed Stock, 18th Sept., 1896.
		Landings	Deliveries		
MAHOGANY	Honduras	Nil.	141 Logs.	1,097 Logs.	1,300 Logs.
	Nicaraguan	"	130 "	775 "	Nil.
	Mexican	206 Logs.	290 "	3,411 "	2,309 Logs.
	Panama	Nil.	Nil.	76 "	224 "
	African	421 Logs.	357 Logs.	1,712 "	451 "
	Cuba	801 "	294 "	2,174 "	4,655 "
	St. Domingo	Nil.	1 "	427 "	1,469 "
CEDAR...H.	Cuba	1 Log.	Nil.	428 "	746 "
	Honduras	Nil.	"	85 "	37 "
	Mexican	116 Logs.	52 Logs.	824 "	261 "
	Paraguay	Nil.	13 "	2,795 "	2,063 "
	Punta Arenas	"	Nil.	Nil.	Nil.
	Pencil	"	57 Logs.	1,420 Logs.	1,912 Logs.
ROSEWOOD	Rio	"	9 Planks	243 Planks	58 Planks
	Bahia	"	19 "	650 "	330 "
WALNUT WOOD	Italian	30 Planks	5 "	656 "	84 "
	Burrs	Nil.	7 Pieces.	13 Pieces.	22 Pieces
	American	71 Logs.	71 Logs.	1,093 Logs.	1,692 Logs.
	Black Sea	Nil.	44 "	399 "	388 "
SATIN WOOD	St. Domingo	26 Logs.	Nil.	457 "	224 "
	Porto Rico	Nil.	"	Nil.	2 "
	Bahama	"	"	"	Nil.
EBONY	Ceylon, &c.	"	1 Ton.	233 Tons.	151 Tons.
COCUS WOOD	Cuba, &c.	5 Tons.	17 "	43 "	14 "
LIGNUM VITÆ	St. Domingo, &c.	2 "	6 "	335 "	75 "
LANCEWOOD SPARS	Cuba, &c.	260 Pieces.	495 Pieces.	8,800 Pieces.	3,908 Pieces.

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THE RELATION BETWEEN RHYTHMIC GROWTH AND VARIETY IN CITRUS FRUITS.

By THOMAS MEEHAN, Botanist to the State Board of Agriculture, Pennsylvania, U.S.A.

The recognition that growth is rhythmic, and not one continuous act, affords a ready explanation of many phenomena otherwise inexplicable; and this is well illustrated by a comparison of various forms of fruit in the orange and other varieties of the citrus tribe.

Occassionally an orange may be found wholly formed inside of another orange, and more frequently an orange will be found projecting from the apex of another—that is partially enclosed, while in another which has been propagated as a distinct variety and called the Navel orange, a very small attempt to form another fruit at the apex is generally seen giving the navel or umbilical appearance from which the variety derives its name.

The morphological unity of the foliaceous and floral part of a plant being conceded, we conceive of the axis as being arrested in its longitudinal development when a flower is being formed. In most oranges, we find the axis still extending a considerable distance into the fruit bnt varying very much in consistency in different varieties. Sometimes it is quite woody, in others it is found cellular and so soft that it can be compressed between finger and thumb; while in some—notably in a variety known as Tangierine there is rarely but a few lines of axis, usualy no axis at all.

The rhythmic waves of growth are not all of equal measure. As in jumping a ditch, a boy may now rest exactly where he lands, and now have to continue several paces before final rest, so does the wave force in growth vary in intensity. In the process of the metamorphosis of a branch with its various modes into a flower and finally a fruit, the expenditure of force in the arrestation of axial growth and the development of the appendages to petals, stamens and carpels is exactly meted to the results,—now it is short of the mark, and the axis starts under another rhythmic movement the next time to be arrested for good and all.

It is this succession of growth rhythms that produces the double fruit oranges, but the phenomenon is not confined to the citrus tribe. In the formation of cones in the coniferous family the branch in its axial growth is usually wholly suppressed; but occasionally, especially in the Larch where the tree is young and in a very vigorous condition, the growth-wave not being wholly exhausted, will make another venture, and a weak shoot from the apex of the cone results. In Rosaceæ the same phenomena are by no means uncommon. One rose blossom * will push out from the centre of another, and a small branch bearing a minature pear has been known to spring from the crown of a pear of normal character beneath it

The main purpose of this paper is to note the remarkable origin of the variety of orange known as the Tangierine, and this by reason of a singular variation in the character of the force in the rhythmic wave. In the primary wave, for some reason yet obscure, it is remarkably weak, and sends the greater part of its effort into the secondary one.

What is usually the small orange within the larger in the double orange, or the minute orange in the apex of the navel variety, becomes the leading and only original fruit:

Once in a while nature furnishes the absolute proof of this morphological conception. It is not rare to have specimens of Tangierines in which are from five to ten abortive carpels at the base of the fruit. In these cases the well defined axis, usually in the common orange, runs through the lower abortion, to be suddenly and finally suppressed when the upper cycle of organs takes its turn to become fruit. The Tangierine has always a flattish or oblate form. The utter suppression of the axis at the point of its formation naturally favouring a lateral growth.

The key herewith furnished, will doubtless disclose to us the secret of the many forms which the citrus tribe often assumes. The length of the lemon as compared with the more globular orange is evidently due to a more rapid advance of the growth wave This naturally leads to a more elongated form. This hypothesis is supported by examining a half section of the lemon taken longitudinally. The axis is much more apparent and more woody than in the orange. It will be found to have come to a rest at the apex of the oval, starting again as from a regular node on the branch, to form a new and weak axis through the nipple which forms such a distinguishing mark of the lemon as compared with the orange. The nipple is possibly the result of the secondary rhythmic growth, which in the Tangierine orange was able to advance to a perfect fruit. From the limited opportunities of examining large quantities of lemons from seedling trees, I have not

* Mr. S. Moxsy lately sent an interesting example. [Ed. Bn.]

been able to demonstrate this as an actual fact as in the case of the orange, but I feel sure some one may meet with an abnormal specimen which will prove the point.

The varying intensity of rhythmic waves of growth may come to be regarded as a leading factor in the development of form. These waves certainly have to do with the varying sexual characters of trees, as I have shown in other papers. The fact brings us near to a certain knowledge of the origin of form, though we have still to learn what causes the variations in the intensity of these waves. Even in these different forms of citrus fruits the varying forces affect fertility. In the case of the Tangierine orange, in which the secondary rhythm has been accelerated to such an extent as to cause abortion in the whole of the lower carpellary system, the seeds necessarily are not formed. In the case of the Navel, where the secondary wave has only drawn part of the force from the lower, it usually results in so much weakening of the latter's power that few or no seeds result. The Navel is usually a seedless fruit. (*Proceedings of the Academy of Natural Sciences of Philadelphia.*)

CEARA RUBBER.

This Rubber was noticed in the Bulletin for March, 1895, and the results were given that were obtained in the Public Gardens.

The following lettter calls attention again to the subject.

Messrs. Cross and Howard differ very much in their remarks on the elevation at which it grows. According to Mr. Cross, it would appear as if the elevation was not above 200 feet, whereas Mr. Howard has seen it at 3,600 feet. It would grow at greater elevations still in Jamaica, and it may be well to try it all over the island. Applications for a few plants to experiment with, should be addressed to the Director of Public Gardens, Kingston P. O.

The price of rubber has risen since Messrs. Silver quoted 2s. 3d. per lb., as the value of some obtained from a tree in Hope Gardens, and Mr. Howard states that the price now is 3s. 3d. per lb.

Mr. Esme Howard to His Excellency Sir H. A. Blake.

Barbados, 2nd October, 1897.

I have been travelling in Mexico and Brazil for some months to examine the habits of the different rubber-producing plants of those countries with a view to finding out which are the most suitable for plantations. In Ceara, Brazil, I bought several thousand seeds of the *Manihot Glaziovii*, which I think will grow well in many parts of the West Indies, meaning to distribute them in various islands for the purposes of experiment. It seems to me that parts of Jamaica would be well suited for the cultivation of this tree, which produces a good rubber fetching at present where well collected and cured the second highest price of any rubber on the market, viz. about 3/3d. per lb.

The *Manihot Glaziovii* will grow well on hill sides in a rocky and rather poor soil. We found it growing in Ceara up to a height of 3,600 feet above the sea. It is a rapid grower and can be tapped in five years after planting, provided it has grown well. I believe a rainfall of about 100 inches or more is most suitable for it, but it will do with much less say 65 or 70 inches.

As I cannot go to Jamaica myself, I take the liberty of sending a packet of these seeds to you, hoping that means may be found to try the plant in Jamaica. I fancy there are already one or two specimens in the Gardens at Castleton. The seeds before planting should have a bit of the hard outer shell chipped off to allow water to get more readily at the germ within, and cattle should be kept from the young plants as they eat them very greedily.

CAROB OR LOCUST-BEAN TREE.

[The Carob Tree has for many years been growing in some of the Public Gardens, but has not proved to be satisfactory. It will probably grow in many dry rocky places in the island where the Guango which bears a similar pod will not flourish; but the results obtained so far have not warranted a recommendation to Penkeepers to plant it.

However, the following *Foreign Office Report* (No. 431, Sept. 1897), by Mr. Neville-Rolfe, H. M. Consul at Naples, places the matter in a new light, and efforts will be made to obtain grafted plants of the best variety.—*Ed.*]

Carob cultivation.—In the course of last spring a well-known gentleman from South Africa made enquiries at this Consulate concerning the cultivation of the carob or locust-bean tree and the possibilities of its introduction into the Cape Colony. The carob is a tree the fruit of which consists of a long pod which not only forms excellent horse-food, but is very largely eaten by human beings, especially children, on account of its sweetness. The pods contain very hard beans which are useful only for seed, as horses leave them in their mangers, and if by chance they swallow them, it is found that they do not digest them. The tree bears, moreover, thick dark ever-green foliage which gives a cool and grateful shade. It grows in many places in the Mediterranean where nothing else will grow, notably on the arid hills of Malta, and it seems certain that in the endless varieties of soil and climate to be met with in the Cape Colony there must be many districts where it would grow freely. The successful result of such an experiment would be simply invaluable to the colony if merely as a supply for horse-food, for one of the greatest difficulties in travelling at the Cape is to feed one's horses, the price of forage in some districts being extremely high, and the supply often distressingly short. Forage, moreover, as it consists of oats with their straw, is not readily portable, but carobs enough for a pair of horses for a day can be carried in a small bag. The carob in Italy grows alongside the oranges and lemons, and there can be no reason why it should not grow with the magnificent orange trees of Wellington, and become as superior to the carob of Italy as the Cape orange tree is superior to its Italian prototype. In places like Graaf-Reinet, and Aliwal North, the success of the experiment seems absolutely certain, while, judging from the way the tree prospers on the dry stone of Malta, where it grows with apparently no soil to help it, there is good hope that it might take kindly to the "Kopjes" near Colesberg, the bush veldt of the Western coast, the lower slopes of the Drakenfelds or among the trees of the Knysna forest. The writer being well acquainted with the Cape Colony has had much pleasure in investigating the matter thoroughly, and, after lengthened consultation with practical arboriculturists, the following modus operandi has been decided upon. First, a sufficient

quantity of seed will be sent out to grow a number of seedlings in different parts of the colony. These seeds will produce carobasters, which will not have a fruit worthy of the name till they are grafted. The strongest seedlings may be grafted in their third year, but it is of no use to graft until the plant is strong and well grown, which may not be till it is five or even seven years old.

General scheme.—A number of plants in pots will be grafted here next spring, repotted in larger pots with plenty of clay, and when the grafts have taken well the trees will be packed, the clay well soaked in water, and it is confidently hoped that they will bear the journey satisfactorily. They will be sent from here in the month of February, and will probably travel viâ England, which seems climatically preferable to the East Coast route, by German steamer to Durban viâ Zanzibar. If the coincidence of the steamers can be secured they may reach Cape Town within a month of their despatch from here, or even less, but if not, we have no doubt that the steamship company will see that the roots are keept carefully wetted while the trees are in bond at the port of origin. It is with the object of keeping the roots wet that they are now being repotted in stiff clay, a soil which is in itself favourable to the growth of the tree.

Details.—Having thus given a general sketch of the scheme, it is necessary for its success to enter into minute detail as to the method to be employed in the cultivation of the trees. We will first take the plants to be exported two years hence, because these are ultimately the most important part of the subject. If they should succeed, the acclimatisation of the tree at the Cape is assured; if they fail, the seedlings will be comparatively valueless for want of grafts. It is the fixed opinion of people here who have studied the subject closely, that there would be no chance of grafts sent out arriving in a condition to be of any value whatever, so that it becomes absolutely necessary to send out the plants themselves; besides, when the plants at the Cape were ready to be grafted, our grafts would be out of season here.

Plants for grafting.—We have already secured some excellent plants, from each of which a large number of grafts should be available. It does not seem possible to secure plants already grafted, for the reason that they are not usually grafted in pots, the operation being performed after they are planted out and have got a good hold on the soil which is to be their permanent home. We cannot graft these plants till May, 1898, nor can we be sure of the success of the operation till May, 1899, when the plants will be sent out. The carob is a tree which cannot be transplanted on account of its tap-root, so that once planted it must remain where it is; it is therefore very essential to plant it in the right place to begin with. In the case of our plants it will be necessary to top them and to cut off every leaf, in order that the sap may not be exhausted by the foliage when it begin to rise. We shall consequently export mere skeletons to the colony, and here again we have another difficulty to contend with, namely, the change of season. The plants will leave here at the end of our winter, and will arrive at Cape Town at the beginning of the South African winter. They will thus have a great strain put upon their nature, and great care will have to be taken of them to enable them to overcome it. This care they will certainly have at the hands of the managers of the Botanical Gardens in the

Colony, so that this is one of the least of our anxieties. The details in this report would therefore be unnecessary, but for the fact that as the experiment will be tried on an important scale, and many of the plants till fall under the care of less capable hands, it is advisable to give very clear instructions.

Potting.—On the arrival at their destination the plants must be carefully potted in garden mould, to which a little old farmyard manure should be added, and the pots must be moved from time to time to prevent the plants striking a tap-root through the hole at the bottom of the pot into the soil, in which case they will certainly perish. They will not require very much water, in fact the climate of South Africa so much resembles that of Naples that were it not for the clay which we must send with them the plants would scarcely require water at all in the Cape winter. If, however, this clay gets hardened it may kill the rootlets which by that time will have spread into it, and give the tree a worse chance, so that the clay must be kept moist. It may be desired to plant the trees out at once, but this should not be done in windy weather, and on the whole it will be safer to pot them, at all events for a few months till they can recover from their journey.

Seedlings.—With regard to the seedlings, they should be sown in pots with proper drainage, and in garden mould, with a slight sprinkling of old, short, farmyard manure. The greatest care must be taken to move the pots often enough to prevent a tap-root being struck through the pot into the ground beneath. Experiments may safely be made by sowing seeds in the spots where they are intended to remain, and grafting them when the plants come to maturity, but this should be done in enclosed gardens or places where the plants can be guaranteed from being choked by weeds, nibbled by sheep or game, or otherwise harassed in their early years. The carob grows freely in dry soils, but, economically speaking, it has been found preferable to raise them in pots. The seeds will be sent out in the pods, as this has proved to be the best method for their preservation. It is desirable to remove the beans from the pods, and soak the beans for four days before sowing them ; the seeds thus gets softened and germinates more rapidly. At Naples the seeds are sown in February and March, but they are apt to sprout very unequally. The majority grow freely and well, but some come up as late as October, and then generally develop weak plants. The strongest seedlings may be potted at the end of the first year, or even as early as November ; the weaker ones at the close of the second. They must be kept in pots till they are finally planted, as they will not bear transplanting, and windy weather should be avoided for these operations. The experiments couducted here show that it takes a minimum of four years and a maximum of seven to produce a plant. A stong plant may be planted out in safety in five years, but mnch depends on the skilful care of the seedlings in the nursery.

Cost of plants.—Each plant brought to maturity in this country is calculated to cost 8*d.*, and it has been found by experiments that it is cheaper in the long run to grow the plants in the nursery than to sow them in the open ground. They are not particular as to soil, and grow freely in clay, if not too wet, in sandy soils, and in the clefts of rocks, where of course holes of about a cubic yard must be dug for them and filled up with soil, drainage being provided in the ordinary way.

Mountain planting.—It is usually necessary to build a rampart of stones in the shape of a crescent on the lower side of the hole to prevent the soil from being washed away. On "Kopjes" and hill sides the trees must be planted on such spots as offer a position, unless the hill has soil enough to be terraced, but on open arable land they should be planted in rows from 12 to 15 yards apart. The intervening ground can be used for garden crops, but these, must not be grown within four feet of the young trees, although the ground round the trees may advantageously be dug over when the rest is prepared for cropping. Exhausting crops, such as corn and mealies, must not be grown, but cabbages and garden produce generally will do no harm.

Grafting.—It is better to let the plants obtain a strong growth before attempting to graft them, the third year being about as early as it is prudent to do it. If a plant is very full of leaf it is desirable to leave it alone and not to graft it at all, for a reason which will appear below, and also because being leafy it may be taken to be a good variety. The season for grafting here is from the middle of May to the end of June, the grafter being careful to see that the bark opens easily. The best plan is to graft on the boughs and not on the stem, leaving the smaller boughs to utilise the winter deposit of sap, which may otherwise prove injurious to the grafts. These boughs can be cut off in the following year. The carob can also be satisfactorily budded, or grafted by sawing off the trunk and cleaving it. In windy situations it will be necessary to bind canes to the grafted boughs to stiffen them, and to prevent the grafts from moving. The best two varieties of carob are both called here the "Honey bag:" one bears a long narrow pod, the other a short wide one.

The object of leaving a fair sprinkling (say 25 per cent.) of ungrafted trees in a grove is the following. The grafted tree produces almost exclusively female flowers, the ungrafted tree males. Unless these flowers are in due proportion there can be no crop; and in fact this was the primary cause of the failure of a carob grove in Sicily, a cause which was discovered and remedied by Professor Bianca. In planting these trees on ordinary arable land great inequality will often be found in the plants, which arises from the fact that the carob cannot support water. Hence, where water accumulates in the subsoil the tree will not grow, whereas, where the water drains away, it will grow freely, and for this reason a hill side is the best situation for a grove.

Prince Belmonte's grove.—Some years ago the Italian Alpine Club agreed that it would be greatly to the advantage of South Italy, and would add materially to the attractions of the mountain scenery, if the Apennines, which are now for the most part quite bare, could be made to grow trees such as there is every reason to believe that they did in more ancient times. They determined to consult Signor Savastano, the professor of arboriculture in the school of agriculture at Portici near Naples, who gave it as his opinion that the mountains where the lentisk and the myrtle grow freely enough could be utilised to produce the more remunerative carob. To the obvious advantage of re-afforesting the mountains, and thus adding to the rainfall, would be added to the production of a valuable crop where nothing saleable had grown before.

The great carob-growing districts of South Italy are in the Bari region on the Adriatic coast, and quantities are exported annually to

Russia and central Europe from Brindisi and the other ports along the coast. Though the tree may be seen in almost any garden here, and is not uncommonly found on the mountains, the only person who has made a hobby of its cultivation is the Prince of Belmonte, who has large properties in the province of Salerno not far from the ruins of Paestum. Besides planting several trees in his shrubbery, the Prince has a long avenue of them leading up to his house, which is particularly interesting, and is, we believe, the only avenue of its kind. The trees are planted 7 metres apart and the largest of them has a trunk of 85 centimetres (about 2 feet 9 inches) in circumference. This tree is 18 years old, and its top is from 6 to 7 metres in diameter, and 4 or 5 in height. In common with the other trees of the avenue the fruit is of the best description, and each tree may be taken to yield annually 50 chilos, or say 120 lbs. of fruit, worth here about 6 shillings. This may be spoken of as the ornamental part of the work, while the plantations of Licosa and Tresina are more on the scale of a commercial enterprise. They are both germane to our present purpose, as they show in what different circumstances the carob will grow and flourish. The Licosa grove is in a plain by the seaside, and the difference of the trees is very remarkable, some of them growing with great vigour, others not flourishing at all. The reason of this must be the existence of land-springs beneath the surface with which the weaker trees come into contact, and by which their growth is checked. There is no other apparent reason, and as the grove consists of about 1,500 trees there is scope for observation. The site is very much exposed to the wind, and in the first attempts at forming the grove as many as 70 per cent. of the plants were lost. There were other causes too which led up to this heavy loss. First, the whole thing being an experiment, they did not know at what period and in what way it was best to graft the trees, and also the grafters had not anything like the skill which they have since acquired.

The grove at Tresina is planted in altogether different conditions. Here we have a hilly country fully 1,000 feet above the sea, and here the outside loss of plants has been 20 per cent., which is not more than occurs in the planting of ordinary forest trees. The plantation consisted originally of 7,000 trees, but has been largely increased year by year, and the Prince expresses every confidence that in a few years' time he will clothe the barren slopes with a mantle of luxuriant green. Professor Savastona asks very pertinently why, if these results can be obtained at Tresina, they should not be obtained elsewhere, and thousands of barren acres of Italian mountains be made useful and productive. And in fact, since he wrote upon the matter, the spread of this cultivation has been steady and continuous. We have shown pretty plainly that Prince Belmonte has attained success only by patient experiments extending over a considerable number of years commercially speaking he is abundantly satisfied with the results obtained, but he does not relax his efforts. He rears some 8,000 seedlings every year, and has a skilled staff to conduct all the necessary operations with the result that he grows a valuable crop on ground which before was absolutely unproductive; and if the landed proprietors of South Africa profit by his experience and are equally persevering, and the tree as is anticipated, proceeds to grow like a weed, its introduction should form a mine of wealth to our industrous colonists. There

is one important advantage that the carob has over other beans, namely, that it does not require threshing. In feeding horses it is usual to break the pod into two or three pieces and to put it in the nose bag or manger mix with bran.

CITRIC ACID.

Raw Material.

Citric Acid is prepared from the fruit juice of three species of Citrus—the lemon, bergamot, and lime; the first of these is the principal source of citric acid. Concentrated lemon juice is chiefly imported from Sicily; a very little comes from Naples or Sorrento. Concentrated bergamot juice is prepared in Calabria and exported from Messina. Concentrated lime juice is imported in small quantity from Montserrat and Dominica. The lemon juice from Sicily is prepared by pressing the inferior fruit, from which the rind has previously been removed, for the manufacture of essence. The so-called "single" juice is then boiled down till its sp. gr. equals 60° on the citrometer (sp. gr. 1. 24); it then forms a dark brown, rather syrupy liquid.

The total quantity of concentrated Sicilian and Italian juice imported to England in 1887, was equivalent to rather more than 3,400 pipes of 108 gallons; the amount used for the manufacture of citric acid was probably equivalent to 3,200 pipes, of lime juice, about 2,000 puncheons of 110 gallons were imported in an unconcentrated condition, and used for the preparation of beverages. About 200 pipes of concentrated lime juice were imported, and employed for the manufacture of citric acid.

Lemon juice has its greatest acidity early in the season (November). The juice of the fine fruit, exported as lemons, has sp. gr. 1.03-1.04; it contains free acid equal to 11-13 oz. of citric acid per gallon. The inferior fruit pressed in Sicily yields a juice containing at the beginning of the season about 9 oz. of free acid per gallon, and at the end of the season a great deal less.

There are other differences between the juice of fine lemon pressed in England, and the Sicilian juice employed for the manufacture of citric acid. The former contains very little combined organic acid, only about 2.5 p.c. of the total organic acid (free *plus* combined) present. In unconcentrated Sicilian juice the combined acid is about 7-9 p. c. of the total. Again, the English pressed juice contains hardly any organic acid save citric only about 1 p. c. of the total organic acid being unprecipitable as calcium citrate. In Sicilian juice about 8 p. c. of the total organic acid is unprecipitable as calcium salt.

The concentrated lemon juice from Sicily is reckoned of standard quality when its sp. gr. is 1.24, and its acidity is equal to 64 oz. per gallon of nominal citric acid. In dealing with trade analysis it must, however, be borne in mind that the "crystallised citric acid" of a trade certificate is not the crystallised acid of commerce, but an acid containing only half the actual amount of water, an acid in fact having the atomic weight 201 instead of 210

$$(C_6 H_8 O_7 H_2 O.)$$

no reason can be given for this practice, which should certainly be abolished. In the present article all quantities of citric acid will be expressed in terms of the common crystallised acid.

The concentrated lemon juice from Sicily contains pretty uniformly 7-8 oz. per gallon of combined organic acid, equal to about 10 p c. of the total organic acid (reckoned as citric) present. Of the total organic acid about 10 p. c. is not precipitable as calcium salt, and is therefore not citric acid; this proportion is, however, by no means constant. Purchases of lemon juice are unfortunately still made on the basis of acidity, and not on the amount of precipitable acid present. Analyses of 895 pipes of concentrated lemon juice by Mr. Grosjean have been published (Town Cham. Soc. Lond. 43,333). The average proportion of precipitable acid was 99-2 p. c. of the free acid, but the range of variation was considerable, individual parcels of juice giving 81.1, 85.8, and 103.6 of precipitable acid p. c. of free.

Concentrated Bergamot juice has a similar sp. gr. to lemon juice, but a lower acidity; it generally contains free acid equal to about 51 oz. of citric acid per gallon. The quantity of combined organic acid is apparently similar to that in lemon juice, namely 7-8 oz. per gallon; but the proportion of combined to total is higher, 12-13 p. c. The proportion of unprecipitable acid is about 13 p. c. of the total. Mr. Grosjean's analyses of 90 pipes of Bergamot juice, show a mean of 98.4 of precipitable acid for 100 of acidity, the extremes being 95.4 and 101.4.

The unconcentrated lime juice of Montserrat has a mean of sp. gr. of 1.036; it contains according to Conroy (Ph. J. 1883, 606) an average of 7.84 p. c., or 12.54 oz. per gallon of free acid. The extremes observed were 6.70-10.05 p. c., equal to 10.7-16.1 oz. per gallon. The juice yields 0.43 p. c. of ash. It contains only a trace of sugar. Warington found the combined acid in two samples 5 p. c. of the total; 10 p. c. of the total acid was not precipitable.

Concentrated lime juice is a viscid liquid, sp. gr. 1.32, and with an acidity averaging about 94 oz. of citric acid per gallon. The combined acid is about 8-9 oz. per gallon. The unprecipitable acid is about 10.14 p. c. of the total. The precipitable acid bears a lower proportion to the free than is the case with either lemon or bergamot juice, the published analyses showing a mean of 93.8 of precipitable acid for 100 of free.

The nature of the organic acid, other than citric, present in lemon, bergamot, and lime juice has not been determined. A little formic acid and acetic acid have been detected in concentrated juice, but the principal acids other than citric are clearly non-volatile and have soluble calcium salts. The acids most probably present are malic and aconitic.

Besides lemon juice, some crude calcium citric, prepared in Sicily by precipitating lemon juice with chalk, is exported into England. It contains about 64 p. c. of citric acid.

Process of Manufacture.

The manufacture of citric acid from concentrated lemon juice is extremely simple. A proper quantity of whiting (levigated chalk) is mixed with water, and heated by steam in a wooden vat provided with a revolving agitator; the concentrated juice is then slowly pumped in, care being of course taken that the whiting is finally in small excess. the liquor never becomes neutral, however long boiling may be continued, or however great is the excess of whiting present; the adjus - ment of juice and whiting is therefore effected by ascertaining if the

liquor effervesces with more whiting, or the precipitate effervesces with more juice. The amount of unneutralised acid is about 1-2½ p. c. of the original acidity of the juice. Pure citric acid is readily neutralised by whiting, malic and aconitic acid are not; the final acidity is thus possibly due to the presence of these acids. Citric acid, however, is not neutralised by chalk if phosphates, and especially ferric phosphates, be present; this fact will also explain the result. It is not advisable to neutralise completely by the use of lime, as vegetable impurities are then thrown down which are afterwards difficult to separate.

The precipitated calcium citrate is washed with hot water on a filter. It is next brought by the addition of water to the state of thin cream, and decomposed, with constant agitation, by the addition of a small excess of sulphuric acid (sp. gr. 1.7.). The occurrence of an axcess of sulphuric acid is known by the liquor affording a precipitate with a strong solution of calcium chloride after some minutes' standing.

The citric acid liquor is then separated from the gypsum, which is washed on a filter. The liquor is evaporated in shallow leaden baths by steam heat. Much gypsum is at first deposited, from this clear liquor is run off and further concentrated. When strong enough to crystalise, the hot liquor is run into a wooden tub provided with an agitator, and the liquor is kept in constant motion while cooling; by this process, known as "granulation," the citric acid is obtained as a crystalline powder. The mother liquor is again concentrated, and salt again obtained by granulation. The process may be repeated a third time. The liquor is then too dark and impure for further crystallisation, and is known as 'old liquor.' The granulated citric acid when drain, and if necessary slightly washed, is redissolved, decolourised by heating with animal charcoal (previously freed from phosphates by hydrochloric acid again concentrated to the crystallising point, and poured into leaden trays about 3 inches deep; the crystals here formed are the citric acid of commerce. Citric acid thus prepared always contains a trace of lead.

The 'old liquor' is diluted with water, and the citric acid it contains precipitated with an excess of whiting, exactly as in the case of the original juice. The liquor is never neutralised by the whiting; this may be either due to aconitic acid formed during the heating of the citric acid liquors, or to the presence of ferric or aluminic phosphate derived from the whiting.

Any considerable excess of sulphuric acid in the liquors, or any overheating, must be avoided, as occasioning decomposition of citric acid. The presence of iron or aluminium in the whiting also occasions loss, as citric acid holding iron or aluminium in solution is not precipitated by calcium carbonate. In consequence of the non-precipitation of iron or aluminium from citric solutions by whiting, the citric liquors of the factory remain nearly pure. however long the work may have been continued, a result very different from what happens in the case of tartaric acid; the purity of citric acid liquors is however obtained at the expense of some loss of citric acid. In a well-conducted factory the total loss during manufacture will amount to 12-15 p. c. of the citric acid in the juice.

The total quantity of citric acid made in the United Kingdom in

1887, was between 400 and 500 tons, of which about half was exported. About 15 tons were imported from Sicily; this was the only import. The acid is chiefly used by calico-printers; it is also employed in the preparation of effervescing drinks and in medicine.—*Thorpe's Dictionary of Applied Chemistry.*

FERNS: SYNOPTICAL LIST—XLVIII.

Synoptical List, with descriptions, of the Ferns and Fern-Allies of Jamaica. By G. S. JENMAN, *Superintendent Botanical Garden, Demerara.*

2. *Vittaria lineata*, Swartz. —Rootstock shortly repent, fasciculate, densely clothed with dark hair-like reticulated serrate scales; fronds linear, 1-4 ft. l. ⅛th in. w., uniform, pendent in dense compact tufts, narrowed gradually and thickened at the base, but with no distinct stipes, glossy, deep green, thickly coriaceous but pliant while green; openly depressed down the back, the under side rounded toward the base, margins as thick, but the edges subrounded both above and beneath; veins slender immersed and concealed, oblique, distant, forming narrow longitudinal areolæ; sori sunk in thread-like very narrow uninterrupted submarginal grooves. Pl. Fil. t. 143. Eaton's Fern N. Am. Pl. 38.

Very common on trees, especially on the banks of rivers at low altitudes, and on rocks and trees in forests from sea level up to almost the very highest peaks Specimens from the mountain forests are dwarf and not often over a foot long. The finest plants grow on the branches of trees that overhang rivers among the lower hills. These are horsetail-like, in dense pendent tufts, 2-4 ft. l. The grooves are narrower and nearer the edge than in the last species, the substance thicker, and the margins not reduced, the corners being merely rounded.

3 *V. stipitata*, Kunze.—Rootstock sub-repent, very short, clothed with minute hair-like dark reticulated scales: stipites tufted, naked or slightly scaly, dark purple, 1-3 in. l. passing gradually into the dark-green fronds, which are linear-ligulate, pendent, 1-3½ ft. l. ⅛-⅜ths in. w., firm, but pliant while fresh, very clear and translucent, the margins slightly thickened, the edge on the underside not rounded; veins immersed very oblique, long, forming very narrow greatly elongated areolæ; sori submarginal, sunk in a narrow continuous thread like groove, falling short of the base and apex.

Infrequent on the branches of trees over rivers, and in very wet forests, chiefly among the lower hills, but ascending as high as 4,000 ft. altitude: most frequent on the banks of Ginger River. St. Mary, gathered also at Old England, below the Government Cinchona Plantations. It grows chiefly in peaty matter, which accumulates about the roots of Bromeliads and on decaying wood. There are only a few fronds to a single tuft, but the plants are generally aggregated in a mass. In growth the fronds are exceedingly tramslucent so much so that the venation ran be clearly seen a yard or two away, in favourable light. The lateral veins are nearly as strong as the midvein; there being no distinct midrib as in the preceding species, above the base of the fronds.

4. *V. remota*, Fée.—Rootstock slender, short, erect, the scales very minute, reticulated, and dark; stipites cæspitose, erect, few to a plant, purple, short, winged by the decurrent fronds to near the base; fronds erect or suberect, $\frac{3}{4}$–1$\frac{1}{4}$ ft. l. $\frac{1}{4}$–$\frac{1}{2}$ in. w., tapering gradually both ways, the apex acuminate, very rarely forked, pellucid, chartaceous, a bright glossy green, pale beneath, margins thin and slightly reflexed or bevelled, sometimes irregularly narrowed and forming a shallow notch in the line; midrib evident, raised on the upperside, the base dark purple; veins close, about 1 l. apart, connected exteriorly within the margin, and also casually interiorly; sori forming a dark-brown band, superficial, or the receptacle, very slightly depressed, continuous or interrupted.

Rare in forests on decaying logs of wood, growing in grass-like masses, gathered at Chesterfield, St. Mary. A well marked but rather anomalous species, distinguished by the superficial broadish bands of sori, the close veins, which casually form medial connections as well as the normal exterior anastomosis, and the distinct midrib. The veins though immersed (as is also the midrib) are slightly raised on the upper side. The texture while fresh is pellucid, and the colour a very fresh bright green.

Genus XXXIV. Tænitis Swartz.

Sori linear, continuous or interrupted, rarely in oblong patches, submarginal, intramarginal or medial, superficial or more or less impressed or sunk in a narrow furrow; veins freely reticulated or the veinlets connected by a transverse longitudinal vein, which forms a linear or elongated receptacle; fronds simple, furcate or pinnate, generally coriaceous, naked or slightly scaly; rootstock shortly repent or free-creeping.

A very small genus, much resembling the preceding, but distinguished by its more superficial sori, generally copiously reticulated venation, stiffer and coriaceous texture of leaf, and erect or less pendent habit. There are barely a dozen species, all tropical, two-thirds of which are American, and the others Asiatic. They are all epiphytal, growing on the branches and stems of trees, mostly in moist districts or situations.

Fronds simple.—	1. T. Swartzii.
	2. T. angustifolia.
	3. T. lanceolata.

1. *T. Swartzii*. Jenm.—Rootstock free-creeping, thick as slender cord, dark tomentose-scaly in the extending part; fronds scattered, 4-6 in. l. $\frac{1}{4}$-$\frac{1}{2}$ in or more wide, acuminate, tapering at the base and decurrent on the short purple petioles, which are $\frac{1}{2}$-1$\frac{1}{2}$ in. l., elastico-coriaceous, opaque, thinly sprinkled with minute peltate fimbriate-edged scales, underside paler than the upper, costæ purple, thread-like upwards; veins immersed, hidden or obscure, reticulated, the areolæ elongated and parallel with the costae and margins, sori superficial, intramarginal, continuous or interrupted, mostly in oblong patches in small fronds, confined to the upper part. *Grammitis elongata*, Swartz. *Mecosorus*, Klotzsch, *Gymnogramma*, Hook., *Polypodium*, Mett.

Common below 2,000 or 3,000 ft. altitude, growing on the stems of bushes and trees, generally near the ground. The fructification is very variable, ranging from patches a quarter of an inch, to unbroken lines two or three inches long. The fronds with the longer lines of sori no one would on first knowledge think of referring to any of the genera above quoted, and therefore I think the species is best associated with *Tænitis*. Indeed narrow soriferous fronds might very readily be taken for branches of *T. furcata*, Willd. so near is the likeness.

2. *T. angustifolia*, R. Br.- Rootstock rather slender, repent, densely clothed with dark, reticulated, hair-like, lacerate-edged, acuminate scales; fronds linear-lanceolate, suberect or pendent, approximate, or rather tufted often, 1 - 1½ ft. l. ½ in. or rather over wide, long tapering to the very acuminate apex, the same to the long-decurrent base, in which the petiole is hardly distinct, coriaceous, naked, the upper side darker, the margins entire, even, thin and rather reflexed, sometimes concealing the sori, the midrib evident beneath, purple in the lower part; veins immersed, copiously reticulated in elongated areolæ, which run parallel with the costæ and margins; sori continuous or interrupted, slightly within the margin, in a shallow or rather superficial groove falling short of both apex and base Pl. Fil. t. 140. Pteropsis, Desv.

Frequent on the branches of trees close to rivers below 2,000 ft. altitude. As in some of the species of *Vittaria* and other similar epiphytal ferns which grow without soil or vegetable matter, the roots are densely tomentose. The fronds resemble most those of *Vittaria remota*, but are longer, more opaque, and may at once be distinguished by the netted venation, which, however, is often quite concealed in the leathery opaque substance. In a young state the thin reflexed margins or outer edges of the grooves, more or less conceal the lines of sori, but at maturity they are exposed and form dark submarginal bands.

3. *T. lanceolata*, *R.*, Br.—Rootstock shortly repent with dense much matted root fibre; stipites approximate or apart, chestnut-brown, 1-2 in. l., erect; fronds erect, lanceolate, ½-1¼ ft. l. ¾-1¼ in. w. tapering both ways, upwards to a long somewhat contracted fertile part, the base decurrent shortly more on one side than the other, coriaceous, stiff, naked, glossy, dark green, midrib distinct, the same colour as the frond, margins entire but repand; veins freely reticulated, forming oblique meshes with free included veinlets; sori marginal, confined to the upper part of the fronds in continuous or interrupted marginal lines, superficial, or very slightly impressed at first; Pl. Fil. t. 132. Pteris lanceolata, Linn. Pteropsis, Desv. Paltonium, Presl. Neurodium, Fée.

Frequent on trees at low elevations growing in erect spreading patches, with densely matted roots. A broader, stiffer, and more lanceolate species than the last, and definitely marked by the bands of sori being more marginal and confined to the rather contracted upper third or less of the fronds, and by the different venation which has rather stronger main veins at intervals, with free included veinlets in the meshes. The venation shows distinctly on the upper side. The margins are so repand that when dry they are quite wavy.

TRIBE XIII, ACROSTICHEÆ.

Fronds usually dimorphous, covering a wide range in form, cutting and habit, the fertile more or less contracted; sori usually diffused

over the whole under surface (and occasionally the upper) except on the rachis and costæ; sporangia stalked, compressed, girdled by a vertical jointed band, splitting when ripe transversely; usually naked and destitute of any involucral covering.

This tribe as here viewed, and represented in this Flora, comprises only a single large genus, in which regardless of diversity of habit, venation and circumscription—which characters authors have adopted for dividing it into several genera—are included all those plants which have naked amorphous sori, and though confessedly an heterogeneous assemblage, the character is an obvious and easily recognised one. They are principally tropical subjects, and have their head-quarters on the islands and mainland of equatorial America, where about two-thirds of the known species exist.

Genus XXXV, Acrostichum, Linn.

Sori diffused in a uniformly even superficial layer over the under, and in a few cases the upper surface of the frond; sterile and fertile fronds (except in one case) distinct, the latter usually more or less contracted; venation free or variously anastomosing; habit and circumscription various.

This well marked genus embraces about 200 species, the majority of which are epiphytal subjects, living among moss and vegetable debris on trees, rocks and decaying logs in damp forests; and of the rest, the majority lift themselves clear of the ground where they begin their growth, and ascend the nearest vertical surface by means of their creeping or scandent rhizomes; so that very few are strictly terrestrial. The barren fronds are permanent, usually for years, but the fertile, which are produced only in season, and are herbaceous or membranous in substance, mature and perish in a few weeks. Some species only fruit during a limited portion of the year, generally in the late summer months.

Fronds simple.
　Veins free.
　　Fronds nearly or quite naked.
　　　Fronds tapering at the base.
　　　　Stipites of barren fronds usually under 1-2 in. l.
　　　　　　1. A. Herminieri, Bory.
　　　　Stipites of barren fronds usually over 2 in. l.
　　　　　　2. A. gramineum, Jenm.
　　　　　　3. A. simplex, Swartz.
　　　　　　4. A. inæqualifolium, Jenm.
　　　　　　5. A. alatum, Fée.
　　　　　　6. A. viridifolium, Jenm.
　　　　　　7. A. chartaceum, Baker.
　　　Fronds shortly tapering, cuneate or rounded at the base.
　　　　Stipites over 2 in. l.
　　　　　　8. A. pallidum, Baker.
　　　　　　9. A. conforme, Swartz.
　　　　　　10 A. latifolium, Swartz.

Fronds more or less paleaceous.
Scales few.
11. A. viscosum, Swartz.
12 A. Huacsaro, Ruiz.
Scales copious but not matted.
13. A. tectum, Willd.
14. A. auricomum, Kunze.
Scales matted.
15. A. muscosum, Swartz.
16. A. lepidotum, Willd.
17. A. squamosum, Swartz.
Scales chiefly on the margins and midrib, paleaceous or hair-like.
Scales more hair-like than paleaceous more or less deciduous.
18. A. hybridum, Bory.
Scales hair-like, confined chiefly to the margins and rib or spread over the surface.
Scales chiefly on the margins, but sparingly over the other surface.
19. A. apodum, Kaulf.
20 A. cubense, Mett.
Scales spread more freely over the surface.
21. A. spathulatum, Bory.
22. A. Lindeni, Bory.
23. A. siliquoides, Jenm.
24. A. villosum, Swartz.
Veins areolated.
Scales hair-like, scattered over the surface.
25. A. crinitum, Linn.
Fronds compound.
Veins free.
Fronds palmate or flabellate.
26. A. peltatum, Swartz.
Fronds simply pinnate.
27. A. sorbifolium, Linn.
Fronds bi-tripinnate.
28. A. osmundaceum, Hook.
Veins united.
Veins united only at the margin.
29. A. cervinum, Swartz.
Veins copiously areolated.
Sporangia not mixed with corpuscles.
30. A. nicotianæfolium, Swartz.
31. A. alienum, Swartz.
Sporangia mixed with corpuscles.
32. A. aureum, Linn.
33. A. lomarioides, Jenm.

CONTRIBUTIONS AND ADDITIONS.

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SEEDS.

From Frank Walker, Launceston, Tasmania.—

Leptospermum lævigatum
Eucalyptus Risdoni
E. cordata
E. urnigera
E. Gunni
E. coccifera
Helichrysum antennarium
H. rosmarinifolium
H. baccharoides
Blandfordia marginata
Styphelia Billardierii
Olearia stellulata, var. angustifolia
O. persoonioides
Anopterus glandulosus
Pimelea drupacea
Acacia longifolia
Clematis gentianoides
Telopea truncata
Drimys aromatica
Casuarina distyla
Metrosideros tomentosa
Sprengelia incarnata
Trochocarpa thymifolia

From Botanic Gardens, Trinidad.—
Aristolochia gigas, var. Sturtevantii

From Dr. Plaxton, Kingston.—
Sapodilla

PLANTS.

From Lady Blake, Moneague.—
Habenaria macroceratitis.

CASTLETON GARDENS.

JULY.

IN FLOWER.	IN FRUIT.
Averrhoa Bilimbi, Linn (The Bilimbi, E. Indies)	Cæsalpinia Sappan, Linn. (Sappan Wood, E. Indies)
Andira inermis, H. B. & K. (Cabbage bark tree, W. Indies, Brazil)	Carapa guianensis, (Crab-wood, Guiana)
Baphia nitida, Lodd (Cam Wood, W. Africa)	Cocos botryophora, Mart. (A Brazilian Palm)
Bauhinia variegata, Linn. (Butterfly tree, India & China)	Cynometra americana, Vog. (Trop. America)
Brexia madagascariensis, Thou. (Madagascar)	Eugenia malaccensis, Linn. (Malay Apple, Malay Islands)
Brownea Rosa-de-monte, Berg. (Rosa-de-monte, Trop. S. America	Garcinia indica, Choisy (Kokam Butter, India)
Calophyllum Calaba, Jacq. (Santa Maria, West Indies & Trop. Amer.)	Garcinia Morella, Desrouss (Gamboge tree, E. Indies)
Caryocar nuciferum, Linn. (Souari, or Butter nut, Guiana)	Gmelina asiatica, Linn. (An East Indian tree)
Cassia siamea, Lam. (India & Malaya)	Heritiera macrophylla, Wall. (Looking-glass tree, India, Burma)
Castilloa elastica, Cerv. (Central America Rubber, Cntr. Amr.)	Imbricaria maxima, Poir. (Mauritius & Bourbon)
Cerbera fruticosa, Roxb, (Burma)	Michelia Champaca, Linn. (Champac tree, India)
Clerodendron macrosiphon, Hook. f. (Trop. Africa)	Omphalea triandra, Linn. (Cob-nut, Trop. America)
Cocos botryophora, Mart. (A Brazilian Palm)	Pachira aquatica, Aubl. (Pachira, Trop. America)

In Flower.	In Fruit.
Cordia alba, Roem. & Schult. The White Cherry tree, W. Indies Cynometra americana, Vog. (Trop. America) Dipteryx odorata, Willd. (Tonquin Bean, Cayenne) Heritiera macrophylla, Wall. (Looking glass tree, India, Burma) Hyophorbe Verschaffelti. H. Wendl. (A Palm from Rodriguez Island) Lagerstrœmia Flos-reginæ, Retz. (Queen's Flower, India & Burma) Michelia, Champaca, Linn. (Champac tree, India) Myroxylon toluiferum, H. B. & K. (Balsam of Tolu, Trop. America) Nerium Oleander, Linn, var. alba (White Oleander, Mediterranean Region) Norantea guianensis, Aubl. (Norantea, Guiana & Brazil) Omphalea triandra, Linn. (Cob-nut, Trop. America) Oreodoxa regia, H. B. & K. (Royal Palm, Cuba) Pachira aquatica, Aubl. (Pachira, Trop. American) Pterocarpus Draco, Linn, (Dragon's Blood tree, Trop. America) Pterospermum lanceæfolium, Roxb. (An East Indian tree) Semecarpus Anacardium, Linn. (Marking-nut Tree, India) Sterculia carthaginensis, Cav. (Chica, Trop America) Stevensonia grandifolia, F. Duncan (Palm from the Seychelle Islands)	Pachira Barrigon, Seem (Barrigon, Panama) Posoqueria longiflora, Aubl. (Guiana) Peterocarpus indicus, Willd. (Rose Wood, E. Indies & China) Terminalia Arjuna, Bedd. (Arjun tree, India & Ceylon) Vanilla planifolia, Andr. (Vanilla, Trop. America) Victoria regia, Lindl. (Royal Water-lily, Guiana)

August.

In Flower.	In Fruit.
Acacia cyanophylla Lindl. (Blue-leaved Acacia, Australia) Artocarpus Lokoocha, Roxb. (Indian Breadfruit, India & Malaya) Averhoa Carambola, Linn (Carambola, India and China) Baphia nitida, Lodd. (Cam-Wood, W. Africa) Bauhinia variegata, Linn (Butterfly tree, India & China) Bignonia magnifica, Bull (Colombian Bignonia, Colombia) Brexia madagascariensis, Thou. (Madagascar)	Cananga odorata, Hook. f. & Thomas. (Cananga, Ilang,India) Castilloa elastica, Cerv. (Centr. American Rubber, Central America) Chrysalidocarpus lutescens, Wend. (A Maritius Palm) Couroupita guianensis, Aubl. (Cannon-ball tree, Trop. Amer.) Copernicia cerifera, Mart. (Wax Palm, Brazil) Cynometra americana, Vog. (Trop. America) Dillenia indica, Linn. (Dillenia, E. Indies)

In Flower.

Brownea Rosa-de-monte, Berg.
(Rosa-de-monte, Trop. S. America)
Calophyllum Calaba, Jacq.
(Santa-Maria, W.Indies & Trop.America)
Caryocar nuciferum, Linn.
(Souari or Butter-nut, Guiana)
Cordia alba, Roem. & Schult.
(The White Cherry-tree, W. Indies)
Couroupita guianensis, Linn.
(Cannon-ball tree, Trop. America)
Davidsonia pruriens, F. Muell.
(Australia)
Eichornia speciosa, Kunth
(Water Hyacinth, Trop. America)
Erythrina umbrosa, H. B. & K.
(Bois Immortelle, S. America)
Erythroxylon Coca, Lam.
(Coca, Andes)
Eugenia malaccensis, Linn.
(Malay Apple, Malay Islands)
Gelonium, multiflorum, A. Juss.
(India, China & Malaya)
Hevea brasiliensis, Muell. Arg.
(Para Rubber, Brazil)
Manihot Glaziovii, Muell. Arg.
(Ceara Rubber, Brazil)
Mesua ferrea, Linn
(Naghas Tree, India)
Miconia magnifica, Triana
(Mexico)
Musa coccinea, Andr.
(A bright red flowering Banana. China)
Norantea guianensis, Aubl.
(Norantea, Guiana & Brazil)
Noronhea emarginata, Thou.
(A Madagascar Tree)
Omphalea triandra, Linn.
(Cob nut, Trop. America)
Oreodoxa regia, H. B. & K
(Royal Palm, Cuba)
Pterocarpus Draco, Linn.
(Dragon's Blood tree, Trop. America)
Sanchezia nobilis, Hook. f.
(Ecuador)
Sarcocephalus esculentus, Afzel.
(Sierra Leone Peach, Upper Guinea)
Semecarpus Anacardium, Linn.
(Marking-nut tree, India)
Stevensonia grandifolia, F. Duncan)
(Palm from the Seychelle Islands)
Tabernæmontana Wallichiana, Steud.
(Sumatra)
Terminalia Arjuna, Bedd.
(Arjun Tree, India & Ceylon)

In Fruit.

Diospyros discolor, Willd.
(Mabola Ebony, Philippines)
Garcinia indica, choisy.
(Kokam Butter, India)
Hevea brasiliensis, Muell. Arg.
(Para Rubber, Brazil)
Imbricaria maxima, Poir)
(Mauritius & Bourbon)
Michelia Champaca, Linn.
(Champac tree, India)
Omphalea triandra, Linn.
(Cob-nut, Trop. America)
Oreodoxa regia, H. B. & K.
(Royal Palm, Cuba)
Pachira Barrigon, Seem.
(Barrigon, Panama)
Phyllanthus Emblica, Linn.
(The Emblic Myrobalan, India & Burma)
Samadera, indica, Gærtn.
(Samadera, India & Ceylon)
Sarcocephalus esculentus, Afzei.
(Sierra Leone Peach, Upper Guinea)

SEPTEMBER.

IN FLOWER.	IN FRUIT.
Wormia Burbidgei, Hook. f. (Borneo)	Averrhoa Carambola, Linn. (Carambola, India & China)
Acacia cyanophylla, Lindl. (Blue-leaved Acacia, Australia)	Cananga odorata, Hook. f. & Thoms. (Cananga, Ilang. India)
Allamanda neriifolia, Hook. (Brazil)	Couroupita guianensis, Aubl. (Cannon-ball tree. Trop. America)
Ardisia tinifolia, Sw. (Jamaica)	Dillenia, indica, Linn. (Dillenia, E. Indies)
Artocarpus Lacoocha, Roxb. (Indian Breadfruit, India & Malaya)	Diospyros discolor, Willd. (Mabola Ebony, Philippines)
Cæsalpinia Sappan, Linn. (Sappan Wood, East Indies)	Eriobotrya japonica, Lindl. (Loquat, China & Japan)
Cassia bacillaris, Linn, (Trop. America)	Erythroxylon Coca, Lam. (Coca, Andes)
Cassia glauca, Lam. (Glaucous Cassia, E. Indies, & Australia)	Garcinia Mangostana, Linn (Mangosteen, Malay Archipelago)
Cassia siamea, Lam. (India & Malaya)	Landolphia Kirkii, Dyer (Rubber Vine, Africa,)
Conostegia speciosa, Naud. (Panama)	Manihot Glaziovii, Muell. Arg. (Cearea Rubber, Brazil)
Coccoloba latifolia Lam. (S. America)	Mauritia flexuosa Linn. f. (Ita Palm, Brazil & Guiana)
Cordia alba, Roem. & Schult. (The White Cherry tree, W. Indies)	Noronhia emarginata, Thou. (A Madagascar Tree)
Crinum Moorei, Hook. f. (South Africa)	Omphalea triandra, Linn. (Cob-nut, Trop. America)
Croton Tiglium, Linn. (Croton-oil tree, India & Malaya)	Tabernæmontana longiflora, Benth. (Trop. America.)
Davidsonia pruriens, F. Muell. (Australia)	
Derris dalbergioides, Baker (Burma, Malaya)	
Diospyros montana, Roxb. (An Ebony tree from India)	
Dillenia indica, Linn. (Dillenia, E. Indies)	
Eriobotrya japonica, Lindl. (Loquat, China & Japan)	
Erythrina umbrosa, H. B. & K. (Bois Immortelle, S. America)	
Eugenia brasiliensis, Lam. (Brazil Cherry)	
Eugenia malaccensis, Linn. (Malay Apple, Malay Islands)	
Heliconia Bihai, Linn. (Wild Banana, W. Indies & Trop America.)	
Heritiera macrophylla, Wall. (Looking-glass tree. India, Burma)	
Hymenocallis caribæa, Herb. (Carribæan Lily, West Indies)	
Manihot Glaziovii, Muell. Arg. (Ceara Rubber, Brazil)	
Mimusops Elengi, Linn. (Elengi, India)	
Musa coccinea, Andr. (A bright red flowering Banana, China.)	

In Flower	In Fruit.
Myroxylum toluiferum, H. B. & K.) (Balsalm of Tolu, Trop America)	
Napoleona imperialis, Beauv. (Napoleona, W. Africa)	
Norantea guianensis, Aubl. (Norantea, Guiana & Brazil)	
Oncidium Lanceanum, Lindl. (Orchid from Guiana)	
Oncidium Papilio, Lindl. (Butterfly Orchid, Trinidad)	
Pachira aquatica, Abbl. (Pachira, Panama)	
Peristeria elata, Hook. (El Spirito Santo, or Dove Orchid, Panama)	
Phyllanthus nivosus, Bull. (Pacific Islands)	
Piper nigrum, Linn. (Black Pepper, India & Malaya)	
Pterocarpus Draco, Linn. (Dragon's Blood tree, Trop. America)	
Quassia amara, Linn. (Quassia, Surinam)	
Ravenala madagascariensis, J. F. Gmel. (Travellers Tree, Madagascar)	
Sanchezia nobilis, Hook. f. (Ecuador)	
Stevensonia grandifolia, F. Duncan (Palm from Seychelle Islands)	
Vanda tricolor, Lindl. (An Orchid from Java)	
Wagatea spicata, Dalz. (East Indies)	
Zizyphus Jujuba, Lam. (Jujube tree, India & Malaya)	

October.

In Flower.	In Fruit.
Cananga odorata, Hook. f. & Thoms. (Cananga, Ilang. India)	Adenanthera pavonina, Linn. (Red-bead tree, Trop. Asia & Malaya)
Cassia bacillaris, Linn. (Trop. America)	Averrhoa Carambola, Linn. (Carambola, India & China)
Cassia glauca, Lam. (Glaucous Cassia, E. Indies.)	Barringtonia Butonica, Forst. (Barringtonia, E. Indies)
Clerodendron macrosiphon, Hook. f. (Trop. Africa)	Bauhinia variegata, Linn. (Butterfly tree, India & China)
Colvillea racemosa, Boj. (A Madagascar tree)	Cæsalpinia Sappan, Linn. (Sappan Wood, E. Indies)
Combretum coccineum, Lam. (Madagascar, Mauritius)	Cananga odorata, Hook. f. & Thoms. (Cananga, Ilang, India)
Cordia alba, Roem. & Schult. (The White Cherry tree: W. Indies)	Cocos botryophora, Mart. (A Brazilian Palm)
Cynometra americana, Vog. (Trop. America)	Couroupita guianensis, Aubl. (Cannon-ball tree, Trop. Amer.)
Dillenia indica, Linn. (Dillenia, E. Indies)	Diospyros discolor, Willd (Mabola Ebony, Philippines)
Eugenia caryophyllata, Thunb. (Clove tree, Moluccas)	

In Flower.

Eugenia brasiliensis, Lam.
(Brazil Cherry)
Eriobotrya japonica, Lindl.
(Loquat, China & Japan)
Ficus indica, Linn.
(Banyan tree, Trop. Asia & Malaya)
Ficus rhododendrifolia, Miq.
(Himalayan Region)
Garcinia Mangostana, Linn.
(Mangosteen. Malay Archipelago)
Gmelina asiatica, Linn.
(An East Indian tree)
Hevea brasiliensis, Muell. Arg.
(Para Rubber, Brazil)
Manihot Glaziovii, Muell. Arg.
(Ceara Rubber, Brazil)
Mesua ferrea, Linn.
(Naghas tree, India)
Morinda citrifolia, Linn.
(The Indian Mulberry, Trop. Asia & Australia)
Myroxylon toluiferum, H. B. & K.
(Balsam of Tolu, Trop. America)
Musa coccinea, Andr.
(A bright red flowering Banana, China)
Pachira aquatica, Aubl.
(Guiana)
Pterocarpus Draco, Linn.
(Dragon's Blood tree, Trop. America)
Semecarpus Anacardium, Linn. f.
(Marking nut tree, India)
Swartzia grandiflora, Wild.
(Swartzia, Trop. America)
Trachylobium verrucosum, Oliver.
(Copal tree, Madagascar)

In Fruit.

Erythroxylon Coca, Lam.
(Coca, Andes)
Garcinia Mangostana, Linn.
(Mangosteen, Malay Archipelago)
Morinda citrifolia, Linn
(The Indian Mulberry, Trop. Asia & Australia)
Myristica fragrans, Houtt.
(Nutmeg tree, East Indies)
Noronhia emarginata, Thou.
(A Madagascar tree)
Ochna Kirkii, Oliver
(Trop. Africa)
Omphalea triandra, Linn.
(Cob-nut, Trop. America)
Pachira aquatica, Aubl.
(Pachira, Panama)
Posoqueria longiflora, Aubl.
(Guiana)
Semecarpus Anacardium, Linn. f.
(Marking nut tree, India)
Terminalia Arjuna, Linn.
(Arjun tree, India & Ceylon)

November.

In Flower.

Amherstia nobilis, Wall.
(Amherstia, India & Malacca)
Bauhinia megalandra, Griseb.
(West Indies)
Cæsalpinia Sappan, Linn.
(Sappan Wood, E. Indies)
Cattleya Skinne i, Lindl.
(Orchid from Guatemala)
Dendrobium Phalænopsis, Fitzg.
(An Australian Orchid)
Diospyris discolor, Willd.
(Mabola Ebony, Phillipines)
Dillenia indica, Linn.
(Dillenia, E. Indies)
Erythrina Crista-galli, Linn.
(Scarlet Coraltree: Brazil)

In Fruit.

Bixa Orellana
(Annatto, W. Indies & Trop. Amer.
Cæsalpinia Sappan, Linn.
(Sappan Wood, E. Indies)
Conostegia speciosa, Naud;
(Panama)
Dipteryx odorata, Willd.
Tonquin Bean, Cayenne)
Eriobotrya japonica, Lindl.
(Loquat, China & Japan)
Ellettaria cardamomum, Maton.
(Cardamon, India)
Garcinia Mangostana, Linn.
(Mangosteen, Malay Archipelago)
Gmelina asiatica, Linn.
(An East Indian tree)
Noronhia emarginata, Thou.
(A Madagascar Tree)

In Flower.	In Fruit.
Fagræa obovata, Wall. (E. Indies)	Semecarpus Anacardium, Linn. (Marking Nut tree, India)
Gmelina asiatica, Linn. (An East Indian tree)	
Hedychium coronarium, Koen (Ginger Lily, East Indies)	
Ixora laxiflora, Sm. (Ixora : Trop. Africa)	
Landolphia florida, Benth. (Rubber Vine, W. Africa)	
Mesua ferrea, Linn. (Naghas Tree, India)	
Musa coccinea, Andr. (A bright red flowering banana, China)	
Randia maculata, DC. (Trop. Africa)	
Rhodoleia Championi, Hook. (Small tree from Hong Kong)	
Stifftia Chrysantha, Mikan. (Stifftia, Brazil)	
Swartzia grandiflora, Willd. (Swartzia, Trop. America)	
Tabernæmontana longiflora, Benth. (Trop. Africa)	
Tectona grandis, Linn. f. (Teak, India)	
Terminalia Arjuna, Bedd. (Arjun Tree, India & Ceylon)	

December.

In Flower.	In Fruit.
Amherstia nobilis, Wall. (Amherstia, India & Malaya)	Andira inermis, H. B. K. (Cabbage-bark tree, W. Indies)
Aleurites triloba, Forst. (Indian Walnut, Trop. Asia)	Barringtonia Butonica, Forst. (Barringtonia, E. Indies)
Artocarpus Lakoocha, Roxb. (Indian Bread fruit, India & Malaya)	Bixa Orellana, Linn. (Annatto, W. Indies & Trop. Amer.)
Bauhinia variegata, Linn. (Butterfly tree, India & China)	Cananga odorata, Hook. f. and Thoms. (Cananga, Ilang. India)
Beaumontia grandiflora, Wall. (Beaumontia, E. Indies)	Cinnamomum zeylanicum, Nees. (Cinnamon, Ceylon)
Brownea Rosa-de-monte, Berg. (Rosa-de-monte, Trop. S. Amer.)	Colvillea racemosa, Boj. (A Madagascar Tree)
Cananga odorata, Hook. f. & Thoms. (Cananga, Ilang. India)	Conostegia speciosa, Naud. (Panama)
Carapa guianensis, Aubl. (Crab wood, Guiana)	Couroupita guianensis, Aubl. (Cannon-ball Tree, Trop. Amer.)
Caryocar nuciferum, Linn. (Souari, or Butter-nut, Guiana)	Diospyros discolor, Willd. (Mabola Ebony, Philippines)
Cassia glauca, Lam. (Glaucous Cassia, E. Indies)	Eriobotrya japonica, Lindl. (Loquat : China & Japan)
Cassia grandis, Linn. (West Indies & Trop. America)	Erythroxylon Coca, Lam. (Coca : Andes)
Cassia siamea, Lam. (India & Malaya)	Fagræa obovata, Wall. (E. Indies)

IN FLOWER.	IN FRUIT.
Cinnamomum zeylanicum, Nees. (Cinnamon, Ceylon)	Garcinia Morella, Desrouss (Gamboge tree, E, Indies)
Cola acuminata, Schott & Endl. (Kola Nut, W. Trop. Africa)	Garcinia Mangostana, Linn. (Mangosteen, Malay Archipelago)
Combretum coccinea, Lam. (Madagascar, Mauritius)	Hibiscus elatus, Linn. (Blue or Mountain Mahoe, W. Indies)
Diospyros discolor, Willd. (Mabola Ebony, Philippines)	Manihot Glaziovii, Muell. Arg. (Ceara Rubber, Brazil)
Dypsis madagascariensis, Hort. (A Palm, Madagascar)	Musa coccinea, Andr. (A bright red flowering Banana, S. China)
Erythrina umbrosa, H. B. & K. (Bois Immortelle, S Amer)	Myristica fragrans, Houtt. (Nutmeg tree, E. Indies)
Eugenia caryophyllata, Thunb. (Clove tree, Moluccas)	Napoleona imperialis, Beauv. (Napoleona, W. Africa)
Erythroxylon Coca, Lam. (Coca, Andes)	Noronhia emarginata, Thou. (A Madagascar tree)
Fagræa obovata, Wall. (E. Indies)	Omphalea triandra, Linn. (Cob-nut, Trop. Amer.)
Hibiscus elatus, Linn. (Blue or Mountain Mahoe, W. Indies)	Posoqueria longiflora, Aubl. (Guiana)
Musa rosacea, Jacq. (A reddish-lilac flowering banana, S. China)	Semecarpus Anacardium, Linn. f. (Marking Nut tree, India)
Musa coccinea, Andr. (A red flowering banana, China)	Swartzia grandiflora, Willd. (Swartzia, Trop. America)
Napoleona imperialis, Beauv. (Napoleona, W. Africa)	Terminalia Arjuna, Linn. (Arjun tree, India & Ceylon)
Norantea guianensis, Abul. (Norantea, Guiana & Brazil)	
Rhodoleia Championi, Hook. (Small tree from Hong Kong)	
Stifftia Chrysantha, Mikan (Stifftia, Brazil)	
Tectona grandis, Linn. f. (Teak, India)	
Victoria regia, Lindl. (Royal Water-lily, Guiana)	

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JAMAICA.

BULLETIN

OF THE

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Report of the Director on the Department of Public Gardens and Plantations for the Year ended 31st March, 1897.

CONTENTS:

ON THE GARDENS.

HOPE GARDENS.

In my Report for the year ended 31st March, 1892, I stated that the total number of plants distributed from Castleton Garden during the previous 12½ years amounted to 220,000. During this past single year about 261,000 plants have been sent out from Hope Gardens alone which is now the chief distributing centre. To grow and distribute in one year more than a quarter of a million of plants is a large nursery business, especially as the plants are not at all of one kind, but very varied in every respect.

A packing shed is very much required to protect those who are putting up the plants from the rains, as it is mainly during the "seasons" that plants are distributed. A seed-house is also required for growing seedlings in.

Attention is being paid to getting the right kind of shade trees in the Nursery, as too dense a shade weakens the plants.

A few of the seedling canes promise well, especially No. 95, but the majority will be discarded after finally testing with the Polariscope.

Experiments are being still continued with the Grape Vines. From a large number of varieties imported from the Royal Horticultural Society's Gardens at Chiswick and elsewhere, probably only 2 or 3 kinds will be found suitable for growing in Jamaica. Varieties of American Grapes and some Persian Grapes have also been imported, one of the latter has fruited, and proves to be a small sweet grape without seeds. A Black Hamburgh Vine bore fruit, ripening in April. An effort will be made to get an earlier bearing next season.

The Superintendent is paying particular attention to the selection of good Ripley Pines, and points out a curious fact in connection with the marking of the leaf of the Green Ripley. If there is a broad red stripe in the centre of the leaf, the fruit will turn out good; in other cases the fruit goes into holes at the bottom and is attacked by ants. Experiments were made with different manures, but no difference was noticed.

Experiments were also made in manuring bananas, but as the water for irrigation was cut off to keep other plants supplied during the drought, no results were obtained.

With regard to budding Oranges, it is still a question what kind of stock is the most suitable both for the lowlands and for elevations of 2,000 to 3,000 feet. At Hope trials are being made of Seville Orange, Sweet Orange and Rough Lemon. The Rough Lemon stocks grow best in the early stages, but a considerable time must elapse before any definite information can be gained about their subsequent growth and their freedom from gumming and other diseases.

From experience of our plantation of Ramie, it is quite evident that in dry districts like Hope it is quite useless to try this cultivation. What might be done under constant irrigation such as can be had near Spanish Town, cannot be ascertained at Hope, as the water is frequently locked off for several hours during the day.

The Superintendent has found that the public prefer to pay 1s. each for Roses obtained by circumposition to 4d. for those raised from cuttings, and the Roses at Hope are now all propagated by the former method.

Orchids, Cannas and Pot plants generally have made a good show during the year.

Slow progress is being made with the extension of the Botanic Garden as distinct from the Nurseries, and plantations of economic plants, but naturally the latter have the first claim on our attention. A few trees have however been planted out.

The boys of the Industrial School are being taught in the Gardens on the same lines as before, and are making good progress.

The number of visitors to Hope Gardens during the year has been more than twelve thousand. When the Electric Tram Line is constructed, and runs past the gates, several alterations must be made to provide for the comfort and pleasure of the visitors, who will then come in much larger numbers.

Castleton Gardens.

The attention of the Superintendent at Castleton has this year been chiefly devoted to the work of thinning overgrown parts of the Garden,

opening up new portions, giving better views of the river and freer access to it, extending the nurseries, and improving facilities for propagation.

It is satisfactory to find that the young Durian is so far doing well. There is a tree in the Bath Garden, but it has never fruited. The young plants at Hope have died, so that it is a matter of some anxiety that the Castleton plant should get a chance of fruiting. It is said to bear a most delicious fruit, so delicious that one learns to neglect its revolting smell.

The Superintendent has the credit of being the first at Castleton to induce the Black Pepper plants to fruit. It requires some management, and in the East it is not allowed to climb higher than about10 feet, the tips being then trained downwards.

The Liberian Coffee continues to bear good crops, and is perfectly healthy in contrast to that at Hope, which evidently suffers from want of moisture. At Hope it is impossible to give all the water that it can have on the irrigation lands near Spanish Town, and great interest is felt in the future of the plantations there. But certainly where there is no possibility of irrigation, it is necessary before planting Liberian Coffee to ascertain whether the rainfall is equal rather to that of Castleton than of Hope.

The Garden is drawing increased numbers of visitors every year; as many as 150 a day have on occasions visited Castleton. There is no doubt that the railway to Annotto Bay has induced many to go who would not otherwise have done so, even although there is a drive from the Station of 9 or 10 miles, ascending nearly 600 feet.

Hill Gardens.

The work of getting the Orange Grove into good order has been continued. Fencing and roadmaking operations have been continued. The work of weeding has been heavy, and experiments are being carried out with growing leguminous plants to keep down weeds, and to increase the nitrogen in the soil.

The stock plants of species of Citrus are growing well, though many of those imported from California died. Large numbers of seedlings and budded plants have been raised and distributed.

Fodder plants, vegetables and canes for settlers have received attention. The potatoes supplied for seed by the Agricultural Society were not suitable, and the results were not better than we expected.

The Bermuda Lily trial shows that while the bulbs multiply quickly, there is no interval of cessation of growth during which they can be taken up, and dried off for export. The only chance seems to be to catch them whilst in flower, lift them then, and cut off the stem when withered

Several thousands of seedlings of the West Indian Cedar have been grown, and distributed to settlers and others, thus encouraging re-afforesting on a small scale.

As Coffee Planters have lately had some difficulty in providing plants for themselves, and have asked for supplies from the Gardens, nurseries have been formed, and plants will soon be ready for distribution,

Seed of Cinchona officinalis (Crown Bark) is now sent every year by request of the Government of India to the Cinchona Plantations on the

Nilgiris, as it has been stated that the bark of trees grown from seed obtained there has deteriorated in quality.

Quinine has been manufactured on the Nilgiris since 1889. It is put up in five grain powders, and sold at a very small charge at 1,550 Post Offices throughout the Presidency of Madras. The nominal charge made enables the poorest to obtain quinine in his need, and this was the original reason for the introduction of the Cinchona trees from South America.

The receipts at the Nilgiris Plantations for last year on the sale of quinine, febrifuge, bark, etc., amounted to 147,527 rupees, while the expenditure was 78,317 rupees, showing a gain of 69,210 rupees.

Kingston Public Garden.

The railings for enclosing the lawns have been obtained, and will doubtless make a great improvement in the appearance of the garden.

The vote for the garden is inadequate, and does not really suffice for the maintenance in a proper condition. The pathways require to be gravelled, the Band Stand and railings round it should be painted, and there are many improvements which could be made with a larger vote.

Several of the large Ficus trees have died without apparent cause, unless it be that the soil round their roots has become quite exhausted.

Bath Garden.

The Garden at Bath is in fair condition, considering the small expenditure, and the drought. If it had not been for the well in the garden, the plants would have suffered considerably; the inhabitants also of the town were so short of water that they were glad to have the opportunity of supplying themselves from the well.

King's House Gardens.

The other Public Gardens have their various special uses, besides serving as Botanic Gardens, *e.g.*, special attention is paid at Hope to the economic cultures of cane, pines, etc.: at the Hill Gardens, species of Citrus; at Castleton where the conditions are so favourable for tropical vegetation, the Mangosteen, Amherstia, Palms, etc., are cultivated; the Parade Garden is a City Garden. The gardens attached to King's House have also their particular function, which is to serve as a pleasure garden attached to the residence of the Governor. The object is not to form a collection of plants interesting only to the planter and the botanist, but mainly to grow such as are pleasing to the eye.

A lily-tank has been provided and a Victoria regia planted in it. It is circular in outline, 3 feet deep, except in the centre where it is 5 feet deep. The overflow water will be utilised for the growth of Nelumbium and other suitable aquatics.

EDUCATIONAL.

Practical Instruction.

The Department concerns itself with giving practical instruction on the lines of "the greatest good of the greatest number." While occasionally time can be spared for individuals, I can only for the most part work on our present system, and send an Instructor where the

demand from one district comes from a large number of people. It is most gratifying to find that the efforts made to supply instruction meet with such a hearty response and grateful appreciation.

It is in the fields in actual touch with the soil and the plants that real good is done. The cultivators know their own difficulties; they are quick and ready to assimilate ideas which are obviously improvements on their own practice, especially when examples, such as pruned cocoa trees, are left on their grounds by the Instructor as models to be watched and followed day after day and year by year.

Schools.

Although instruction is sometimes also afforded to school children, it is not possible to give the continual repetitions which are necessary with children who are not so intent on earning their bread as their parents. What is absolutely necessary is a daily instilling of elementary agricultural ideas into the minds of the children by their school teachers.

Hope Industrial School.

The Hope Industrial School at Hope Gardens is giving a good training to a small number of boys which will fit them for agricultural work when they leave.

The Superintending Inspector of Schools writes:—"The Hope Industrial School obtained at last inspection the total number of marks qualifying it for a first class, but failed to reach first class standard in writing. It takes a better position as an elementary school than six-sevenths of the schools of the Island."

The boys over 12 years of age have only 2 hours a day at reading, writing and arithmetic in school, and those under 12 only 3 hours at the usual school subjects; the former working the rest of the time in the Hope Gardens, and the latter in and around the school buildings.

All have half an hour's daily instruction by the Superintendent of Hope Gardens in the theory and practice of gardening. There is no doubt in my mind that this practical teaching and questioning on the work that they are occupied with during most of the day, sharpens their wits, and enables them to make better use of their time in school.

The following is from Mr. A J. Hopwood's Report, Master in charge.

"On the 1st April, 1896, there were 27 boys in the Institution. During the year 15 boys were admitted, 3 were discharged, 1 absconded, his time expiring shortly after, 7 were transferred to Stony Hill, and 1 to Alpha Cottage, and 1 died in the Union Poor House. The number of boys at the end of the year was 29, the increase being 2. The average rate of increase for the past six years has been 2. Of the boys transferred to Stony Hill, 2 were for repeated acts of misconduct, 4 because they had been committed for criminal offences, and one was a case of Yaws. One of the boys discharged was delivered to a relative on special application; one is now working in the Hope Gardens; the third obtained private employment.

"The daily routine has been kept up. Of the 42 boys who have been more or less inmates of the Institution during the year, 19 were boys above, and 23 boys below 12 years of age. The older boys have worked in the Hope Gardens for $1\frac{1}{2}$, and 3 hours in the morning and afternoon respectively: the younger boys have been occupied as usual

in keeping the buildings and grounds in order. In general the boys have been engaged as customary in performing various domestic duties, and in the planting and caring of fruit trees and ornamental shrubs.

"On the 1st October an important change took place in the curriculum for boys above 12 years of age, in consequence of which they have been spending 12 hours only in the Elementary school instead of 18 as formerly.

"The demonstrations by the Superintendent at Hope Gardens have been regularly attended by all the boys. Lessons have been given during the School year in cultivation of grapes, cocoa, coffee, pineapples and oranges, including proper methods of applying remedial measures for scale insects. They have also had short courses on the structure of plants and on gardening operations.

"The Elementary School was examined on the 13th August by R. B Strickland, Esq. and took 56 marks, a total increase of 8 marks. The full 6 marks in Elementary Science (including Practical teaching in Agriculture) was obtained. With regard to the above mentioned change which took place in the curriculum for boys above 12 years of age, the 12 hours have been exclusively devoted to reading, writing and arithmetic, and elementary geometrical drawing, Scripture being included in the reading lessons and explained on Sunday. The boys below 12 years have been instructed as usual in all the subjects prescribed by the Code.

"The buildings are all in good order. General painting and the erection of a Verandah around the additional Dormitory by the Public Works Department were carried out in the early part of the year. A portion of the Stables has also been altered into two small rooms.

"The health of the boys has been on the whole good. A boy suffering from skin-disease in an aggravated form (Pemphigus) was sent by order of the Surgeon to the Union Poor House on the 9th July. He got almost well, and for a time improved, but symptoms of tuberculosis rapidly developed, and he died there on the 21st October. Another boy who had remittent fever was removed to the Public Hospital on the 25th November and returned on the 5th January. A very delicate boy suffering from an attack of influenza with a tendency to tuberculosis—necessitating the employment of a temporary Nurse—was also removed to the Public Hospital on the 5th January and returned on the 20th February. In addition to general directions in cases of accidents, notes on nursing have been furnished from time to time by Dr. Cargill.

"Two changes took place among the Warders during the year—one in the month of June and the other in the month of October. The staff, consists of the Master in charge, two Warders, and a woman as Cook, who does as much as possible the duties of a Matron.

"Prayers have been read daily in the Institution, and the Sunday Schools have been regularly held. On Sunday the boys as usual attend Public Service at the Grove Church—religious instruction being given at the School once, and occasionally twice a week by Rev. H. F. Kirton.

"The best interest has been shown in the School. On the occasion of his visit on 11th May, His Excellency Sir Henry Blake was accompanied by Hon. E. Parsons, Custos of the Cayman Islands. The Official Visitors have been :—Honbles. Jas. Allwood, (Actg. Col. Secy.) W.

Fawcett, T. Capper, Dr. C. B. Mosse, S. C. Burke: Their Lordships the Bishop of Jamaica and Bishop Gordon, Rev. H. H. Isaacs and A. Robinson, Esq. On Christmas Eve Mrs. Cradwick, as on other Public Holidays distributed gifts of different kinds to the boys from herself, Miss Cooper of St. Andrew, and Miss Usher and Mrs. McRea of Kingston. This kindness was much appreciated by all the boys. The boys were all allowed to join the Annual Treat at Shortwood Industrial School on the 6th January—being kindly invited by Miss Johnson. They thoroughly enjoyed themselves as on former occasions. A free MagicLantern Entertainment was kindly given in the School room by Messrs. C. J. Brandon and Son of Kingston on the 24th March. It was greatly enjoyed by the boys. Mr. C. H. Grossett of Port Antonio was good enough to present the School with a number of coco-nut sprouts—a gift which was also much appreciated."

Reports on Practical Instruction.

The following reports are by Mr. Cradwick;—

Portland and St. Mary.

I beg to make the following Report on demonstrations given in Portland and St. Mary:—

Tuesday, 14th April, 1896. Tranquillity. Demonstrated in the School room to about 70 of the School children, afterwards in the ground of Mr. Robt. W. Murray, on the planting of kola, chocolate, coffee, budding of oranges, pruning of chocolate and coffee. Gave instruction as to the curing of coffee and cocoa, and distributed leaflets on growing and curing cocoa and kola.

Mr. Murray has made good use of the instruction imparted to him during my previous visits, andwas very pleased to see me back again to get still further instruction. His cultivation of over thirty acres of cocoa, coffee and kola is very creditable to him.

Three other land owners attended the demonstration, and these also testified to the benefits they had derived from the demonstrations; they were particularly interested in the orange budding.

Kola, coffee, cocoa and oranges all grow most luxuriantly. I measured kola trees 2 years of age, which were 14 feet high. The trees had leaves over 20 inches in length. Kola plants 10 months old had attained a height of 5 feet. An orange tree 3 years old bore 112 oranges. A tree from seeds planted December, 1893, bore in Autumn of 1895 eighteen fruits.

Wednesday, 15th. Charles Town. Gave a demonstration in the fields of Mr. Jos. Welsh early in the morning, on budding oranges, pruning cocoa, coffee, and also dilated strongly on the evils of crowding plants, and of mixing up crops.

There were a good many kola trees about 10 years of age, none of which fruited before they were 7 years old. But I do not think that they can be taken as a fair test as to the time trees would bear in the locality, as they were planted far too near to coco-nuts, to say nothing of cocoa, bananas, canes, etc., which must have retarded the fruiting period for some 2 or 3 years. Then a demonstration was given in the fields of Mr. Prestwich, who had attended previous demonstrations in Mr. Sutherland's fields, and had honestly endeavoured to carry out the instructions given. But as his cocoa and coffee were much older than

Mr. Sutherland's and had gone wrong before my visits, he waylaid me on my way to Charles Town in order to get instruction on his own old trees.

Still further along the road another settler, Mr. Wallen, was waiting for me to inspect his field. The inspection developed into another demonstration. Mr. Wallen had made excellent use of the instruction gained the previous year, and the further instruction imparted to so energetic and intelligent a man was a very pleasant task.

Later lectured in the Charles Town Schoolroom to about 20 adults and a large number of school children, and afterwards gave a lengthy demonstration in the field of Mr. Sutherland.

Mr. Sutherland's field was in quite young chocolate when I first visited Charles Town, and has been the place selected by me on each visit for the chief demonstration. Although a little is left to be desired in the way of thinning out the trees, the field is such a vast improvement on the usual style that it serves admirably as a model to others, especially as it is quite close to the important Buff Bay River Valley road.

Thursday, 16th, Belvedere. An extremely wet morning quite spoiled the day, as the people in this very scattered district did not expect to see me at all, only four men appearing, but these four were thoroughly in earnest and very grateful for previous advice. In the two fields visited, Mr. Thos. Gray's and Mr. Henry Colthirst's, the improvement observable from last year was very great, and the two gentlemen were very grateful for the great improvement which is visible in their fields.

Friday, 17th, Enfield. The Rector, Rev. W. Taylor, said, that in consequence of the late heavy and continuous rains he had been unable to hold any services on Sunday, and in consequence, although, he said, the people were very anxious to see me, it was impossible for them to be fully aware of my coming, and only six people turned up. Two of these had come a long distance on the off chance, and were particularly anxious to get a lesson in budding. A demonstration was given in the grounds of Mr. C. Maxwell on pruning coffee, cocoa, planting kola and budding oranges. Mr. O. Maxwell's cultivation has greatly improved since my previous visit, and he expressed great gratitude for the help I I had been to him.

Monday, 20th, Black Hill and Rodney Hall Valley. Although the morning was fine, noon saw heavy showers of rain which continued throughout the afternoon, and although people here were quite keen on the meeting only about 10 people turned up. A lengthy demonstration was an impossibility, two short ones were given however one in Mr. Francis Minott's ground and one in Mr. Uter's, the demonstrations being on pruning and transplanting coffee, pruning cocoa and on the forking and draining of the heavy land and the budding of oranges.

Tuesday 21st, Swift River. Lectured in the Schoolroom to about a dozen people and a number of school children and afterwards demonstrated in the fields of Mr. Winter and Mr. Holworthy on budding, pruning and planting coffee and cocoa, also inspected the Teacher's garden and gave him advice as to its better management and the better arrangement of it, on a definite plan, and pointed out to him the evils of mixing up his crops.

Wednesday 22nd, Bybrook. Only four people turned up at Bybrook,

two Messrs. Burgess and Mr. Sutherland. The whole afternoon was spent in their fields. The Messrs. Burgess were very anxious that I should visit their lands last year and as there was so small an attendance this year I gave them the benefit of it. They had made good use of the information gained last year and I am sure the instruction imparted this year will also be put to a good use by them. The three hours occupied by the demonstration on pruning coffee, cocoa, budding oranges and giving advice on various matters in connection with the soil was quite enough for one day, for most of the land was steeper than the roof of a house. I also discussed the curing of produce with them and gave advice on it.

Thursday 23rd, Birnamwood. Not a soul was present at Birnamwood, so devoted the afternoon to the School Children. The school is large and comprises many boys and girls apparently of about 16 years of age; they appear to be much interested in Agriculture.

Last year in the Glebe I dug round and manured an old and very forlorn-looking coffee tree, the scholars then being present, the improvement exhibited by the tree this year is little short of marvellous and is a standing object lesson much observed by all the people and the boys and girls of the school. The whole piece of coffee has vastly improved having been manured and forked and pruned to some extent by Mr. Cole by my advice.

General report on the tour. I was disappointed at the small number of people who attended but the weather was very bad both before and during my journey; only one day had been fine during the preceding week, and I had but one fine during the tour, consequently the people had quite given up expecting me. But at the same time I was very much encouraged by the improvement visible in several of the grounds visited.

I noticed throughout each of the different valleys visited that oranges looked exceptionally well, no borer or ants trouble them. I saw no signs of dying back at the points of the branches or any other signs of delicacy of the trees, most of the trees had a quantity of fine fruit ripening up and a huge crop of the regular season's fruit as well. Some trees must have had four or five hundred fruits ripening up now. The valleys on the north side appear to me to be the finest land of any I have seen for orange cultivation but almost the whole of the land on the route of the new mountain road is well adapted to the cultivation. On the north side the risk of the trees suffering from drought is reduced to a minimum and the finest produced is of the finest in flavour and appearance.

The land on the north side is also admirably adapted for kola and cocoa, and the higher lands for coffee. At Mr. Mason's property nutmegs are also growing beautifully; plants four years of age are 10 to 12 feet high and have commenced to bear. His cocoa has yielded three times as much this year as last, a wonderful rate of increase due to good cultivation. Mr. Mason's cocoa-dryer leaves little to be desired; it has a drying capacity of 10 barrels and will dry freshly washed chocolate in 48 hours without danger of burning.

Westmoreland.

I beg to report that on Saturday the 29th of August, 1896, I went to the Bluefields district of Westmoreland for the purpose of lecturing

there on fruit culture, and also inspecting the sites which Mr. Laurence Tate is willing to offer to the Government for the purpose of establishing an experimental fruit farm.

On Monday the 31st August I inspected the various sites which Mr. Tate is willing to give the lease of for a term of years.

I first carefully inspected the sites proposed on his own property "Shafston", then proceded to Grand Vale, the owner of which Mr. King, is willing to grant the lease of any land the Government might select. I examined the proposed sites on Grand Vale, after which we visited "Forest" another property owned by Mr. King. I went carefully over the different pieces of land which Mr. Tate thought might prove suitable and finally came to the conclusion that "Forest" would be the most advisable spot to advise the Government to select if they decide to establish the fruit farm.

"Shafston" grows grapes well, and a great advantage in having the farm there would be that it would be immediately under the eye of Mr. Tate, who is a very enthusiastic cultivator. But there is not a very large population near Shafston, and the people who live thereabouts are apparently better off than those people who live in the district round Forest.

"Grand Vale" is wet with a clay soil not suited for grapes, and is out of the way.

Forest is situated almost entirely in St. Elizabeth, and near a poor district called "The Grove." It is extremely hot, has a fine black sandy loam soil, and is well drained. It would be admirably adapted for an experimental grape plantation and could be easily visited by a large population who apparently would be only too glad to find a method of increasing their incomes.

That most of the district from Black River to Ferris is well adapted for grape culture is abundantly proved by the vines which are already growing in several "yards." These vines are very badly treated, yet they grow and bear much better than one could expect.

The grapes found fruiting, with the exception of those at Shafston, are the Black Barbarossa, a grape of poor flavour, but large and showy and evidently one capable of existing under the greatest difficulties.

At Shafston Mr. Tate has the following fruiting vines:—Barbarossa, Muscat of Alexandria, Gros Colmar, Foster's Seedling, Raisin de Calabre, Black Hamburgh, Black Alicante.

The first named was fruiting very heavily, the second almost equally so, while of course there is no grape to be compared to it for flavour. As far as I could judge from one visit, there are only four grapes worth growing in that district, the two just mentioned, "Foster's Seedling" and Black Hamburgh. Foster's Seedling grows most vigourously, and although not a fine flavoured grape, it fruits heavily and is a nice looking grape.

"Black Hamburgh" is not a vigorous grower but it bears a grape that ripens two or three weeks sooner than any of the others. It also ripens all the berries on a bunch together which many of the other black grapes do not. This is especially the case with Barbarossa and it is a great draw-back to it, half a dozen green berries often spoiling the appearance of an otherwise grand bunch.

Tuesday, September 1st. Demonstrated at Salem on budding oranges,

thinning grapes, and pruning coffee. A good and appreciative audience of over 50 men. At Salem there is a large vine of the Barbarossa variety which has borne heavily for between twenty and thirty years.

St. Ann.

I beg to submit the following Report on a lecturing tour in the Parish of St. Ann.

Monday, March 29th, 1897, Bamboo. I walked about the district with the Rev. J. P. Hall, made myself known to the people whom I saw working in their grounds, had little chats with them, showed them how to bud, and in this way awakened an interest in the district that will I am sure lead to good results.

Tuesday, March 30th. Lectured to a meeting of five or six hundred people in the Tabernacle at St. Jean d' Arc, one of the biggest meetings that I had ever had, owing to its being thoroughly advertised by the Hon. Dr. Johnston.

Wednesday, March 31st. Spent the day in looking over various cultivations which I had visited the year before and was much pleased to see the improvements, and to hear from the owners that the improvements were entirely due to my efforts on previous visits. At night lectured in the Court House to an assembly of about 60 men, nearly all landowners and men of the right stamp.

Thursday, April 1st. Lectured in the Church of England Mission Station at Clarke Town. The room, not a small one by any means, was simply packed and many people had to stay outside. I was told that never but once before had such a number of people gathered in the building and that was on the occasion of a visit of the Assistant Bishop.

Friday, April 2nd. Gave a demonstration on Mr. Ormsby's property and gave him also some advice about his grapes. In the evening lectured in the St. Ann's Bay Court House, here again the house was packed until there was not even standing room.

Subject dealt with:—

Treatment of the soil, coffee, oranges, grapes. The treatment of the soil was chiefly confined to digging, how to do it and the reasons why it should be done.

Coffee: the evils of over-crowding, neglecting to prune, and the neglect of proper shading.

Oranges: The budding was fully explained and demonstrated; hints were given as to the suitability of stocks, and the folly of allowing good trees to get covered up with creepers, wild pines and mistletoe.

Grapes: The growing of grapes was fully explained.

Seeds of the shade trees Bois Immortelle (Erythrina umbrosa) were distributed and directions for their treatment were given. Wherever I go, I notice almost identical mistakes with the treatment of coffee by the peasantry, namely overcrowding, neglecting to prune, and either shading the coffee until it can scarcely exist for want of air and light, or exposing it to full power of the sun, but gradually in every district where my visits are repeated, I see one or two carrying out my instructions and in this way I think the good works is bound to spread.

The treatment of the soil is little understood, but with this the

peasantry are also making experiments on my suggestions, digging up, manuring and liming their lands. and this also is bound in time to tell.

With regard to oranges, when people start to look after their trees, they are apt to do more than the trees can stand, and I am careful to impress on them the necessity of careful continued systematic pruning and cleaning.

With reference to grapes, at St. Jean d'Arc, I saw a vine two years old only, putting out a fine crop of grapes, whether they will ripen or not of course depends on the treatment they get, and also on the variety.

Mrs. J. H. Levy of Brown's Town informs me that she formerly grew grapes but that they were always just getting ripe when the Autumn rains set in, which spoilt them; this difficulty could in all probability be got over by growing a variety which would ripen in a shorter time. There were many people at St. Ann's Bay who had cultivations of various kinds which they were wishful for me to visit but as I had to hurry home on Saturday leaving St. Ann's Bay at 4 a.m. I had no time to do so.

Demonstrations were also given at Kellits on 29th July, at Darliston, 5th August, 1896, at Salem, 23rd February and Shafston, 24th February, 1897.

STAFF.

Lady Assistants in Herbarium and Office.

A vacancy occurred for a lady assistant in the Herbarium, and the conditions governing the appointment were distributed to candidates. It may be of interest to state the conditions here.

Work in Herbarium.

(1) Drying plants.—As soon as the plants are brought in by the collectors, they are placed between sheets of drying paper, under weights which are varied according to the texture, thickness, etc., of the leaves and flowers. The sheets are changed once or twice a day at first, and afterwards at intervals of 2 or 3 days until they are quite dry. The leaves and flowers require a great deal of manipulation in order to make them assume, when dry, the characteristic habit of the plant, and exhibit the technical marks which distinguish the species. The plants are washed over with a solution of cyanide of potassium to kill any insects as far as possible that would otherwise destroy them. Collectors attach a particular number to all specimens collected from one plant, with notes of locality, colour of flower and fruit, height, elevation, etc., added for quotation afterwards in botanical works; and the greatest care is necessary so as not to misplace the labels and thereby cause confusion.

(2) Mounting specimens.—The specimens that are to be laid into the cabinets are mounted on sheets of paper by applying a mixture of gum arabic and gum tragacanth to one side, laying them on the sheets and again putting them under weights.

(3) Placing in cabinets.—As soon as the mounted specimens are ready they are arranged in the cabinets in regular order according to the scientific system of botanical works, so that any given plant can be at once found in its proper place for comparison with specimens

which require to be named. The whole series of cabinets form the permanent departmental herbarium. The collection has frequently to be gone over, examined, and cyanide of potassium applied whenever there is a trace of attacks by insects or fungi.

(4) Duplicates.—The duplicates are all named and numbered to correspond with those in the cabinets, and are distributed to various Herbaria.

(5) Requirements in Assistants.—All these operations require the greatest care, neatness and accuracy. The Assistants should know at any rate the elements of botany, and be able to draw accurately the outline of a growing plant, and the parts of a flower and seed vessel to show their anatomy.

Work in Office.

(6) A great deal of copying for the office has to bedone by the type-writer, and it is advisable that the Assistants should be able to use it.

Other work consists of cataloguing books, etc., for the Library.

Remuneration and Conditions of Employment.

(7) The remuneration is at the rate of £40 a year, with £36 as house allowance, altogether £76 a year, payable monthly.

Twelve days are allowed annually as holidays, at the discretion of the Director, besides the public holidays. A month's notice on either side, without reasons assigned, will be considered sufficient to terminate the engagement.

DISEASES OF PLANTS.

Coffee.

Various species of coffee are being grown in the gardens experimentally.

Liberian has done well for years at Castleton, and as the only difficulty, namely suitable machinery, has been overcome, there is now no reason why it should not be cultivated in districts which either have a plentiful rainfall or a system of irrigation, and at low elevations where Arabian Coffee will not produce a paying crop.

Some of the coffee planters expressed alarm at the introduction of coffee from Kew or anywhere else, and the following letter was written by me on the subject:—

31st October, 1896.

Sir,

I have the honour to acknowledge your letters of 22nd and 28th instant.

I regret to think that you are still uneasy about the possibility of introducing Hemileia with Coffee plants from Kew, and I will therefore try to be more clear with my reasons for thinking that you need not have the slightest apprehension.

The whole life history of the Hemileia has been exhaustively studied and worked out in Ceylon by Dr. Marshall Ward, who is now Professor of Botany in the University of Cambridge. Professor Ward spent two years in this investigation giving up his whole time to it, and there is no disease affecting either plants or animals that is better known.

There is no Hemileia disease on the West Coast of Africa, nor in Kew Gardens; and therefore it cannot be transmitted from Africa through Kew to Jamaica.

It is quite possible that the spores of Hemileia might be carried to Kew on seeds, or in ordinary correspondence, or in the clothes of travellers, just as they have been carried to Fiji and elsewhere, and just as they may at any time be carried to Jamaica by globe-trotters landing in Kingston and making an excursion to the Blue Mountain Peak.

But precautions are taken with plants and seeds at Kew, which cannot be taken with excursionists to the Peak, so as to prevent any risk.

But assuming that the ordinary precautions of a scientific establishment like Kew were unavailing and that some traveller from Ceylon, to take an absurdly extreme case, had actually infected Coffee plants destined for Jamaica with Hemileia spores, the conditions of the temperature and moisture of the air in the plant houses at Kew are the most favourable to the germination of the spores, and spores that remained inactive so long as they were quite dry would within 48 hours grow in the presence of moisture and heat in those plant houses. Any which fell on the soil or on the wooden sides of plant-cases would germinate exactly in the same way as they would on the Coffee leaf, but their existence would be terminated as soon as the nutritive substance of the spore was exhausted. I may illustrate this by reminding you that a Coffee seed may germinate, and will grow, producing leaves, in pure sand and pure water as long as the nutritive material of the seed is available, but as soon as this is used up in the growth, the young seedling must die unless it is planted out in soil. Just in the same way spores of Hemileia will inevitably germinate, given the favourable conditions, and will as inevitably die, unless the spores are actually on the leaf of a coffee plant, and penetrate the "breathing pores."

Supposing that some of these spores have fallen on the leaves of a Coffee plant in the Kew plant-houses. They will germinate probably in 12 hours. If they have not germinated within 48 hours they are dead and will never germinate. From their germination to the "diseased spot" making its appearance on the leaf, the time varies from 8 to 19 days, 13 or 14 days being the usual time.

Plants would be kept in Wardian Cases at Kew before despatch to the Colonies long enough to ascertain and to make sure that they had contracted no disease and were perfectly sound and healthy

But even if such precautions were not taken, and the plants became infected on the very day they were leaving Kew, the disease would have developed by the time they had arrived in Jamaica, and would be so evident to the naked eye that the plants would be immediately destroyed on opening the Wardian Case at Hope Gardens.

The spores of Hemileia can only infect Coffee through the "breathing-pores" of the leaf. They may germinate in any other position, but invariably die, even on the leaf, if the germinal tube does not,in its growth, come across one of the "breathing pores" and penetrate it.

You allude to the plant-diseases known as "smut" and "ergot." The life-history of smut in corn is of quite a different character, being specially adapted to the life-history of the plant it attacks. The spores cling to the seed, and remain in the ground at rest like the seed itself until the latter germinates. The spores germinate at about the same time as the seed, and although the germinal tubes are unable to

penetrate the hard skin of the seed, they can easily push their way into the soft body of the seedling, making their way through the tissues and coming to maturity in the flower as soon as it appears. It is only at this particular time in the life of the corn-plant that smut can successfully attack it.

Ergot is a disease of grasses which is different from smut. It attacks the flower, and assumes the form of large grains, which are in this case also the resting stage of the disease, remaining quiescent through the winter months until the grasses, corn, etc., are flowering when spores are formed in the ergot to be carried by the wind to attack the flowers. It is a disease which is also quite different in its life-history from that of Hemileia.

Smut or ergot in corn and Hemileia in coffee cannot be considered analagous; and because smut may attack the seed corn when germinating, and yet be not noticeable until the plant flowers, it is not possible to argue that a similar process may take place with the Hemileia in Coffee. Infection has been tried in every way with the Hemileia spores, and the only possible mode of infection is through the breathing-pores of the leaf. The disease runs its course within certain definite limits of time, and the journey from England to Jamaica is practically equal to a period of quarantine. To prohibit the landing of a coffee plant which is healthy on arrival from England, would be equivalent to perpetual banishment from Jamaica of anyone who had once been in a place or ship infected with small-pox.

There is infinitely more danger in admitting into the Island letters and travellers from Ceylon than Coffee-plants from Kew, and if the latter be considered a source of infection, it is about time to proclaim permanent quarantine against the whole world.

I have, etc.

W. Fawcett,

During the Session of the Legislative Council, a rumour arose that a planter had imported coffee plants from India, which caused anxiety.

The matter was finally arranged by the Hon DeB. S. Heaven, representing especially the Coffee Planters of the Blue Mountains, and the Hon. J. T. Palache, representing especially the Coffee Planters of Manchester, and myself, approaching His Excellency the Governor, who then issued a Proclamation forbidding the introduction of seeds or plants of Coffee from any other source than Kew Gardens, and then only when imported by the Director of Public Gardens and Plantations.

Coco-nut, &c.

I have examined in several parts of the Island a large number of examples of so called disease of the Coco-nut, in one case travelling to a property near N. Negril Point.

In very many instances I believe the unhealthiness and death of the palms is due entirely to the unsuitable nature of the soil and climate. This is eminently so in the case of the Palisadoes plantation. So long as the Government, through this Department, undertook the care of the Coco-nut palms; when bush was cleared, pigs and goats kept out, and the trees manured, they throve and bore fairly well. But from the time that the Government leased the plantation in May, 1887, the trees have rapidly deteriorated, and very many have died out altogether. My

opinion is that it would not pay expenses for the Government to maintain it, and I doubt whether it would pay any private individual even if he lived on the spot, unless he could get a constant supply of water, or unless he could utilise the land for other purposes.

The Liguanea plain is a dry district, and like the Palisadoes quite unfit for the growth of the coco-nut unless water can be supplied artificially.

In some instances I found a large beetle (*Strategus titanus*), attacking the "cabbage" of coco-nut palms, thereby giving opportunities for the attacks of various parasitic fungi, which soon destroyed the terminal bud, and led to the death of the tree. In other cases the large white grub of the same beetle was seen gnawing the roots.

I also noticed the base of a diseased trunk of a coco-nut riddled with the holes of a small boring beetle, and on cutting it down found the passages made by the insect very numerous, some containing the white grub of the beetle, and the whole of the tissue of the trunk smelling strong of a fermentation set up as a consequence of the attack.

In other instances I could find no specific cause of unhealthiness except the drought, and I believe that with the return of rains, these would soon recover.

I have also examined portions of various diseased plants sent to me by post, but as a rule it is necessary to examine the plant where it grows.

It is probable that an unhealthy condition of a plant whether due to want of water, to too great abundance of moisture in the soil keeping out air, or to some other cause, may lead to such abnormal growth or want of growth, that insects and fungi are able to make the successful attacks which they could not accomplish in health. This consideration accounts frequently for the appearance of scale-insects, which again disappear with the return of the normal conditions of the climate.

It is advisable however to keep a close watch on all plants, and by attending to early symptoms, prevent the disease or pest running its course and becoming epidemic. The risk of a disease spreading is enormously increased where plants are cultivated all together on a large scale, and I anticipate that growers of Orange trees and Grape vines will have to pay strict attention in future to diseases which only become important as we begin to grow their hosts on an extensive scale.

Notes on the subject of diseases of plants due to the attacks of insects and fungi occasionally appear in the Bulletin.

HERBARIUM.

The following are new additions to the flora of Jamaica, obtained during the year:—

New Genus, Species and varieties described from Plants found in Jamaica.

Loranthaceæ:

Phoradendrum tetrapterum, Kr. et Urb. (Engler's Botan. Jahrb. xxiv.)

P. quadrandulare, Kr. et. Urb., var. gracile, Kr. et Urb. (l.c.)

P. Wattii, Kr. et Urb. (l.c.)

P. Campbellii, Kr. et Urb. (l.c.)
Dendrophthora Danceri, Kr. et Urb. (l.c.)
Phthirusa Jamaicensis, Kr. et Urb. (l.c.)

Orchideæ :

Homalopetalum jamaicense, Rolfe (Hooker's Ic. Pl. 2461).

Musci :

Leucobryum Jamaicensis C. Muell. (Bull. de l'Herbier Boissier, v.7.)
L. subglaucum, C. Muell. (l.c.)
Entosthodon paucifolius, C. Muell. (l.c.)
Mnium rigidum, C. Muell (l.c.)
Polytrichum glaucicaule, C. Muell. (l.c.)
Catherinea synoica, C. Muell. (l.c.)
Bryum chlorosum, C. Muell. (l.c.)
B. cygnopelma, C. Muell. (l.c.)
B. mammillosum, C. Muell. (l.c.)
B. ripense, C. Muell. (l.c.)
Pilopogon glabrisetus, C. Muell. (l.c.)
Thysanomitrium Jamaicense, C. Muell. (l.c.)
Dicranum retinervis, C. Muell. (l.c.)
D. Harrisi, C. Muell. (l.c.)
D. longicapillare, C. Muell. (l.c.)
Leptotrichum pseudo-rufescens, C. Muell. (l.c.)
Angströmia Harrisi, C. Muell. (l.c.)
A. Jamaicensis, C. Muell. (l.c.)
Symblepharis Jamaicensis, C. Muell. (l.c.)
Pottia glauca, C. Muell. (l.c.)
P. nanangia, C. Muell. (l.c.)
Trichostomum lamprothecium, C. Muell. (l.c.)
Barbula recurvicuspis, C. Muell. (l.c.)
B. ferrinervis, C. Muell. (l.c.)
B. purpuripes, C. Muell. (l.c.)
Zygodon Jamaicensis, C. Muell. (l.c.)
Macromitrium cacuminicolum, C. Muell. (l.c.)
M. altipes, C. Muell. (l.c.)
M. peraristatum, Muell. (l.c.)
Schlotheimia ciliolata, C. Muell. (l.c.)
S. pellucida, C. Muell. (l.c.)
Helicophyllum Jamaicense, C. Muell. (l.c.)
Phyllogonium globitheca, C. Muell. (l.c.)
Pilotrichella eroso-mucronata, C. Muell. (l.c.)
Hookeria dimorpha, C. Muell. (l. c.)
H. obliquicuspis, Muell. (l. C.)
H. Harrisi, C. Muell. (l c.)
Stereophyllum Jamaicense, C. Muell, (l. c.)
Microthamnium minusculifolium, C. Muell. (l. c.)
Cupressina arcuatipes, C. Muell. (l. c.)
Rhynchostegium rigescens, C. Muell. (l. c.)
Brachythecium Jamaicense, C. Muell. (l. c.)
Thuidium perrigidum, C. Muell. (l. c.)
Fissidens austro-adiantoides, C. Muell, (l. c.) (found in a previous year.)

SPECIES AND VARIETIES FOUND FOR THE FIRST TIME IN JAMAICA.

Myrtaceæ:
Gomidesia Lindeniana, Berg.

Compositæ:
Achillea Millefolium, Linn.

Chenopodiaceæ:
Chenopodium murale, Linn.

Piperaceæ:
Peperomia maculosa, Hook.

Loranthaceæ:
Phoradendrum trinervium, Griseb., var. Domingense, Kr. et Urb.

Euphorbiaceæ:
Euphorbia Preslii, Guss.

LIBRARY.

The following is the Catalogue of the works placed in the Library in addition to those already acknowledged as contributions in the monthly Bulletins. The names of donors are added in square brackets.

Anderson (J.) Colonial Office List for 1896. London. 1896. 8vo.

Boissier (E.) Icones Euphorbiarum. Geneve. 1866. Fol.

Campbell (Prof. D. H.) The Structure and Development of the Mosses and Ferns. London. 1895. 8vo.

Candolle (C. de) Nouvelles Recherches sur les Pipéracées. Genève. 1882. Fol.

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REPORTS OF SUPERINTENDENTS.

Hope Gardens.

The following Report is by Mr. Wm. Cradwick, Superintendent:—

Nursery.

I stated in my annual report for 1895-96 that the importance of the Nursery at Hope could hardly be over estimated. When one looks at the list of plants distributed from Hope during the past year I think it will be admitted that the statement was correct.

We have endeavoured to send out the best plants possible, and to bestow the greatest care in the packing and despatching of them. We have to work under the most adverse circumstances, as we have practically no shelter under which to pack and address plants. The majority of them are sent away during the rainy seasons and very often we are compelled to work out in drenching rain at the risk of catching cold with all its attendant ills, or disappoint people who have ordered plants.

The same care has been bestowed on the appearance of the Nursery as formerly, and with the same difficulty as regards our nomadic labourers.

The remarks made in my last report with reference to seedlings still hold good, the treatment with kerosine being almost a specific against their being carried off by insects.

The difficulty of making provision for soil for the large number of plants put into bamboo and other pots, increases every year, the renewal of the beds for seeds and for transplanted nursery stock is also a serious matter entailing a great deal of labour; the soil gets exhausted very quickly, chiefly on account of the continuous watering necessary at Hope.

Continual thinning of trees in the nursery is necessary to prevent the overshading of the young plants, in fact there seems to be no end of the work, especially of "odd jobs" in a nursery, and for which, at the end of the year, there is nothing to show.

The hedges planted around the nursery have been very helpful during the late fearful drought in checking the passage over the nursery of the hot dry winds so prevalent during one period.

All trees with large leaves will be removed from the nursery as fast as the trees with fine leaves have grown sufficiently to take their place. Besides casting too dense a shade and causing injury to the young plants by drip, the large leaves will sometimes, when they fall, lodge on a small plant, and if not removed in a few hours, particularly in hot damp weather, will kill it.

The list of plants sent out from Hope is appended.

The nursery is now well stocked with plants, there being about 30,000 orange plants, 17,000 kola, 30,000 transplanted Liberian coffee plants and fully 90,000 awaiting that operation, a good stock of cocoa, cedar, mahoe, lignumvitæ and yoke wood, and as near as can be estimated, about 30,000 other ornamental and economic plants.

The propagation of roses by circumposition has been a great success, so much so that I have now abandoned the propagation by cuttings entirely. We raise very fine plants of the best sorts by circumposition, which readily sell at 6d. or 1s. each, when inferior plants raised from cuttings will not fetch 4d.

Economic Plants.

Nutmegs. The nutmeg trees ripened their fruits nicely, one tree had nearly 700 fruits on it, but the crop seems to have been more than it was capable of bearing, for this year it has not grown during the season when it should and gives very little promise of fruit.

There are two distinct varieties of nutmegs growing at Hope distinct both as to the fruit and the foliage of the trees.

One tree grows very vigorously with large, dark green leaves with the branches spreading out, bearing fine large elliptical fruits, but not in any great quantity. The other tree grows upright, the leaves have less colour, the fruits are very plentiful, 700 on one tree, but they are round and very small, and the tree appears to be much less vigorous than the other which produces the elliptical fruits.

Coffee. The old Liberian Coffee trees do not look well. After they were first exposed to the air and light by the removal of other plants which had grown up around them, and after they had been forked round, manured and kept constantly watered, they made a fine spurt looking green and healthy and starting to grow nicely. But it was only a spurt, although they have again been manured and kept watered.

The young trees of Liberian Coffee which are now 2 years old have thriven moderately well. Some are no more than one foot in height, while some are as much as five feet and have branched nicely. Two

have blossomed a little, but many of them have been much troubled with scale insects. The soil is only fair, but good holes were dug for these plants, they were well manured, they are nicely shaded by bananas and have been kept well watered.

The small plantation of 137 Arabian Coffee shrubs, 18 months old, has done well. The majority of them have reached a height of 5 feet at which they have been topped. Some have berries, while a great many were a perfect sheet of blossom during February. These plants received exactly the same treatment as the Liberian Coffee.

The Coffee trees have all had two dressings of farm-yard manure well forked in, and they are kept regularly watered, and weeded. Some of the trees which were not at one time looking well, were manured with Jadoo manure, but there was no apparent result.

The plants of Abbeokuta Coffee received from Kew seem perfectly healthy, with the exception of one or two being troubled by scale insects in a similar manner to ordinary Liberian Coffee.

The plants of Coffea stenophylla are doing fairly well.

Seeds of the supposed Mocha Coffee were received from the Secretary of the Jamaica Agricultural Society. They have grown nicely and have been planted out.

Cocoa. The number of large cocoa trees has been reduced as there were still a few trees of inferior varieties which it was thought wise to remove. It is intended as soon as sufficient shade has grown up to replant the empty spaces with plants of the best varieties.

Sugar Cane. All the new seedling Canes have been increased by double their number, and plant canes of all the varieties will be available for testing this year. A large quantity of the No. 95 variety has been propagated. If we only had had our usual rainfall, tops would have been available for distribution in April in large quantities, but in consequence of the severe and prolonged drought few wll be ready before the end of May. A large quantity of good tops will be ready for the autumn planting, it is proposed to largely increase the area planted with this variety at Hope. Many of the seedling canes seem to have no constitution at all, making very unsatisfactory growths, and when this is the case with the care and attention they receive at the Gardens, I think they are not likely to improve outside.

No. 95 grows well as a plant cane, our plants averaging fifteen canes to a stool, it has a good top, our rows are six feet apart and yet it covers the ground completely; our second ratoons of this variety are also promising well in spite of the severe drought.

Nos. 1, 5 and 116 are still as vigorous as ever.

Po a-ole of the older canes still leads as a vigorous growing cane, second ratoons averaging twenty canes in a stool.

Grape Vines. The Vinery at Hope is fast becoming a very interesting and useful institution.

Last year we were greatly troubled with "Maybugs" which did much harm to the vines. There has been no such trouble this year. Owing to the dead leaves of the Teak trees which were infested with scale insects, blowing among the vines, many of them became badly infested with scale insects. These were easily got rid of by the use of an insecticide made of Telola soap supplied by Messrs. T. Christy & Co. of London. It was recognised however that had the vines been

fruiting last year the destruction of the scale insects would have meant very serious damage to the crop. During the Spring therefore when the leaves, as usual in the Spring, all fell from the Teak trees fire was run through the plantation, which destroyed the scale insects. The pruning of the Grape Vines was carried on at the same time, and great care was taken to burn all prunings which were not needed for cuttings. All such growths were carefully washed in preparation of Telola soap. Then the whole of the vines were thoroughly washed to clean off any scale insects which were on them, and painted over with a mixture of soot, sulphur, and cow manure, thus ensuring the destruction of all the eggs of the scale insects. It is early yet to venture an opinion as to the success of grapes at Hope, but my present opinion is, and in this I am borne out by that eminent grape grower, the Rev. W. Griffith, that the hot lowlands near the sea are the places peculiarly adapted for grape growing and that the elevation of Hope (600 feet) is much against it. We shall, however, have about one hundred vines, each bearing a little fruit this year, and the quality of the fruit will largely determine the question. Six black Hamburgh vines, pruned on the 10th of December, ripened up very nice fruit indeed in April. The bunches were not large, as one might expect from this variety, but the berries were large of a fine colour and flavour. Three bunches were exhibited in the Collegiate Hall on the occasion of Dr. Morris's lecture and were admired by all who saw them. These vines will be pruned in September and October of the present year to see if we can ripen fruit in February and March. Earlier than that is perhaps not possible at Hope, although in districts like the lowlands of Manchester, St. Elizabeth and Westmoreland they probably may be ripened in January.

The vinery at Hope will always be, to a large extent, experimental. It is important now to determine—

1. The best varieties:
   - (a) the heaviest cropper;
   - (b) the finest looking grape;
   - (c) the best traveller;
   - (d) the period at which they are ready to cut with a view of sending them long distances.
2. The best methods of training whether on arbours, fences or otherwise.
3. The best method of root cultivation.
4. The best method of pruning.

With reference to varieties, so far as it has been possible to determine at Hope, the varieties to be grown on a large scale must be selected from the following:—

Black Hamburgh.
Muscat of Alexandria.
Alicante, (black).
Raisin de Calabre.

A vine bearing large bunches of fine black grapes was also brought from King's House to Hope but unfortunately the label was lost in

the transplantiug. This is with perhaps the exception of Gros Colmar, the most vigorous I have seen; growing nearly 40 feet during last season, the canes made being nearly two inches in diameter.

Of other varieties tried Gros Colmar has turned out a failure, it produces large quantities of big bunches, which have large berries up to the time when they begin to colour, then they split and fall off.

Monukka and Trebbiano have also been given an extensive trial but have failed to produce any fruit. A large number of varieties have been received from the Royal Horticultural Society's Gardens, Chiswick.

Many plants have been raised; two or three plants of each variety have been planted out for a trial at Hope, the rest being distributed to the public.

Persian varieties have also been received and are growing well.

The following varieties of American species have been received and planted out, but at present are not looking very promising. Delaware, Hartford, Concord, Niagara, Mailtra, Catawba, Moore's Early, Empire State, Yves.

At present the methods of cultivation followed are almost entirely English, and what is known as the extension system. I have followed this plan, for the following reasons:—(1) that I thoroughly understand it; (2) that the enormous growths made by the vines in Jamaica seem to indicate that the repressive measures carried out by the Continental field grape growers would entail endless labour, with so far as I can see at present, no particular object to be gained. We have, however, this year started to give the Continental methods a trial.

Pines. As stated in my report for last year experiments in manuring pines were being carried out, artificial manures, ashes and farmyard manure were used, but no result from either was visible.

As far as I am able to judge in the short time that the pines have been under observation, much seems to depend on the size and age of the sucker which is used for planting also on the time of the year at which it is planted. A good stout healthy sucker; about 15 inches long, planted just after the heavy October seasons seems to be the right kind, and seldom fails to make a good strong plant which will fruit the following year. Large suckers planted out in the spring time start to fruit almost immediately and by so doing exhaust themselves.

There are two well defined varieties of Ripley Pine to begin with, usually called the red and the green; the red has a plain red leaf, the green has a pale green leaf, with red stripes situated on different parts of the leaf, the stripes being very pronounced in some plants varying from a dark red stripe an inch in diameter to none at all, as far as my observations go at present it is only when the Green Ripley has the broad dark red stripe and that situated in the centre of the leaf that the plant is worth growing; the totally green leafed plant, or the plant with a narrow stripe especially when the stripe is on the edge of the leaf instead of in the centre is not worth anything, the fruit produced usually having holes near the base into which ants creep and by eating the fruit start it rotting.

Whether good cultivation would improve the varieties and produce a preponderance of plants with the correct stripes, whether bad cultivation causes marking to deteriorate, can only be demonstrated by

actual experiment, but there is little doubt in my mind that unless the plant has the correct marking it is useless to expect good fruit from it.

Bananas.—15 rows of the plants each were planted for the purpose of testing the effects of different manures, the ground was carefully prepared and the plants throve well at first, but when the long drought settled down and it became a question of providing enough water to keep them alive, it was soon apparent that the experiment was doomed to be a failure.

Oranges. The budded trees by the glass house have grown well but have fruited very little.

In consequence of the importance which the orange industry has assumed of late, an Orange Grove of nearly three acres has been laid out at Hope; here a thorough trial of the merits of different varieties of Citrus as stocks will be thoroughly tested at present we have the following plants growing :—

18 Tangierine on rough Lemon Stocks.
18 Sweet Oranges on rough Lemon Stocks.
19 Sweet Oranges on Sour Orange Stocks.
19 Sweet Oranges on Sweet Orange Stocks.
6 Imperial Lemon on Sweet Orange Stocks.
10 Imperial Lemon on rough Lemon Stocks.
5 Grape Fruit (Castleton var.) on rough Lemon Stocks.
6 " " " " on Sweet Orange Stocks.
12 " " on rough Lemon Stocks.
4 Melrose Shaddocks on rough Lemon Stocks.
32 Navel Oranges " " "

Mangoes. Quantities of seedlings have been transplanted into beds, these are transplanted about every four months in order to compel them to make plenty of fibrous roots; as soon as they are large enough they are put into large sized clay pots and used for grafting.

Durian. I regret to have to report that the Durian after growing nicely in a pot, died soon after being planted out.

Ramie. The old plots of Ramie continue to thrive according to the treatment they have received, that which was planted in good land has thriven fairly well, that which was planted on thin soil has not thriven at all.

The new plot of 3 chains planted at the request of the Agricultural Society in November at a cost of £1 0s. 0d. per square chain, planted exactly as described in the leaflet, has owing to the severe drought, grown very badly. In fact with our very limited and uncertain rainfall growing Ramie as a commercial venture would be utterly out of the question. If the plants are put in the beds in the way advised in the pamphlet and they are properly cared and watered, plants can be raised in large quantities very rapidly.

Correspondence—The Correspondence for the year is 4,409 letters received, 5,349 letters despatched.

Buildings.—The need for a seed house is intensified, and we also want badly a new plant house. We still have to pack and despatch our plants in the open air, getting drenched to the skin when it rains.

Roads, Fences, &c.,—Sixteen chains of Roads from the Superintendent's House down have been repaired, the gradient here being steep this piece of road requires repairing oftener than the other parts.

The path through the Divi-Divi avenue has also been regravelled and most of the paths in the nursery. Very little has been done to the fences most of these having been thoroughly repaired last year.

Ornamental Plants.

Rose Garden.—The rose garden has been kept in good order, the number of plants of the better kinds has been increased, and the number of the inferior kinds decreased.

A few good roses are always popular, and plants of them are always in great demand.

We have given up attempting to raise plants of the good varieties by cuttings, raising them wholly by circumposition. By this method we get a strong, healthy plant without wasting wood, a great feature, as nearly all the good roses are slow growers.

Cannas, &c.—Cannas still continue to prove what a valuable class of flowering plants they are for our dry district.

All the ornamental plants specially mentioned in last year's report have done well, except *Chickrassia tabularis,* which died on being removed to its proper geographical position.

Pot plants.—The quantity and quality of these have maintained the standard of former years.

Orchids.—The orchids have made a grand show throughout the whole year.

The following have flowered for the first time:—Lælia tenebrosa; Peristeria elata; Bifrenaria aurantiaca; Epidendrum osmanthum; Cattleya Schroderæ; Lælia glauca; Epidendrum bicornutum; Dendrobium giganteum var superbum.

Laelia glauca is considered a difficult species to flower in cultivation, the only plant which flowered at Hope was one growing on one of the Divi-Divi trees, those in baskets did not flower. They will be transplanted to the trees. Many of the epiphytal orchids have been found to thrive better when grown on blocks of tree fern than when grown in the usual peat mixture; this I ascribe to two reasons, first that the tree ferns do not rot and become nasty in the same way that the peat so rapidly does, and secondly that the roots of the orchids being able to bury themselves deeply in the tree-fern-blocks, are not damaged by cockroaches as they so often are in the baskets; the cockroaches are easily able to dig among the peat and eat off the soft young points of the roots. A new floor has been put into the orchid house, which has greatly improved the appearance of it, as well as enabled visitors to walk through to see the orchids dryshod. The fern house still continues to be a great source of attraction, especially to visitors from abroad.

Geographical plan of Gardens.—The work of laying out Hope as a Botanic Garden on a design to follow the natural Geographical distribution of the plants to be grown there, is a work of large dimensions,

especially when conflicting interests are taken into consideration. All kinds of experiments have to be carried out, which cannot be delayed; and besides there are the frequent droughts which make it useless to put out plants unless they can be well watered.

The following work has been carried out in connection with the scheme. Four acres of land have been cleared of weeds and bush, thoroughly forked, cleared of large quantities of stones, nicely levelled and planted with Bahama grass; this in the Tropical African section. After the planting of the Bahama grass, the work of establishing it is by no means done, in fact it is hardly begun; for the watering in such a dry year is very expensive; and the weeding which must be done is endless.

The following trees have been planted in the Malayan and East Indian section :—Chonemorpha Griffithii; Ficus elastica; Ficus religiosa; Ficus infectoria; Ficus indica; Mimusops Elengi; Cordia Myxa; Eugenia malaccensis; Citrus decumana; Cananga odorata; Nephelium Litchi; Leea sambucina; Gynocardia odorata; Bassia latifolia; Acacia cyanophylla; Rhododendron indica; Morinda citrifolia; Livistona chinensis; Rhapis flabelliformis; Chickrassia tabularis; Wrightia tinctoria; Excœcaria Agallocha. In the Australian Section: Dendrocalamus strictus; Casuarina Cunningahamii. Near the Chinese Section—Diospyros discolor.

I hope during this year to carry out a greater proportion of this work than heretofore but of course the same difficulties present themselves year after year; each acre of land that is brought into cultivation makes the daily routine grow larger.

Hope Industrial School—The theoretical teaching has been carried out on the same lines as in previous years, my aim being to make the theoretical teaching the interpretation of the practical operations carried on in the Garden. The boys can carry out details of planting, preparing land, pruning, budding, tc., and give clearly and intelligently their reasons for so doing.

Insecticides.—During the past year I have paid a good deal of attention to the question of the destruction of scale insects, and tried many formulæ for making insecticides. The most effectual insecticide, in fact, the only effectual one on scale insects which I have used is the Telola insecticide—this mixed with water usually kills scale insects after two or three sprayings at intervals of three or four days.

Jadoo.—Experiments were carried out with Jadoo as a soil and as a manure. As a soil for Begonias, it was as good as the best and most carefully prepared soil obtainable, and perhaps a trifle better. Mixed with ordinary soil I could not see, with one exception that it did any good at all; the exception was with orange seeds, it prevented the "damping off" so prevalent in young orange seedlings.

As a manure I have tried it with the utmost possible care on Arabian Coffee, and it did not make the slightest difference to it.

The Jadoo liquid tried on a Bahama grass lawn was equally ineffectual.

Visitors.—In conclusion, I am glad to be able to report that the Gardens are becoming much more popular, the number of increasing every year. As many as 586 have visited the Gardens in one day, the total for the year being 12,037.

Plants Distributed.—Sold.

Economic Plants:—

Liberian Coffee	...	22,134
Sweet Oranges	...	14,110
Tangierine Oranges	...	3,795
Sour Oranges	...	228
Grape Fruit	...	6,488
Ramie	...	11,120
Kola	...	1,855
Nutmegs	...	7,816
Cane Tops	...	17,061
Cacao	...	2,387
Rubber plants	...	372
Arabian Coffee	...	217
Grape Vines	...	413
Miscellaneous Fruit and Economic plants	...	6,237
		94,233
Ornamental Plants	...	15,319

Free Grants.

Economic Plants:—

Miscellaneous (including Timber and Shade Trees)		7,240
Ramie Roots	...	142,672
Ornamental Plants	...	4,481
Total number of economic Plants distributed		244,145
Total number of ornamental Plants distributed		19,800
Total number of Plants distributed	...	263,945

Seeds distributed. 131 Cocoa pods, 1,000 Sweet Orange, 1,000 Sour Orange, 1½lbs. Lignum Vitæ, tobacco seeds (5 vars.) and 20 pkts. of various seeds.

The elevation of the Garden is 700 feet above sea-level.

The average annual mean temperature is 77° 4 F., and the average annual rainfall 52.83 inches. The amount of rain that fell during the year was 31.48 inches, being 21.35 inches below the average. April, May, September and November, were the wettest months, and January, February, March and June the driest.

The mean temperature was 77° 5 F. The Meteorological tables for the different months are given on page 307.

Castleton Gardens.

The following Report is by Mr. Wm. Thompson, Superintendent.

I have continued on the same lines as I had been doing the previous fifteen months when I returned to my duties at these gardens, namely:—

Taking steps to facilitate the working of the garden, pruning trees, and shrubs, thinning out useless ones, planting young plants to increase

the collection of both economic and ornamental trees and shrubs, billing down bush to extend the garden, extending space in nursery, looking to the quality of the plants sent out, making potting sheds, plant sheds to grow tender plants under, watering arrangements, labels, walks, etc.

I am pleased to say after two and a half year's hard work, I have accomplished this, and from this time I hope to be able to attend to collecting and planting in the Garden native plants and such imported plants as would be of use.

I am sorry to say the Garden is still in want of a seed house in which to raise seeds by artificial means. Every year we lose quite half of the seeds received because there is no house for their germination, in which the temperature would not fall too low at night and early morning. This is a reproductive work which would pay for itself in a few years.

It is still important that other buildings such as a seed, specimen and store room and a proper office should be provided at these Gardens.

The number of visitors to the Garden is increasing fast. During some days in the past year we have had as many as 150 in the gardens. Many take the train from Port Antonio to Annotto Bay, and then drive from Annotto Bay to the Gardens.

There is not nearly enough accommodation for visitors in the way of shelter.

A large number of plants have been sent away from the Annotto Bay railway station. The Castleton Post Office is also used for sending away seeds and plants.

Letters despatched number 1195 and 643 letters were received.

The walks on the economic side of these gardens have received the usual amount of hoeing, weeding, and raking. Fresh gravel has been put on the walks when needed. The old gutters on these walks have been repaired and fine new cement gutters made to prevent the heavy rains washing the gravel off the walks.

The old public road that ran through the north part of the garden up to some provision grounds, has been closed and another walk six chains less in distance and to the north of the old walk has been made. People are thus prevented from walking through that part of the garden at night, and a fence has been put up to keep out stock.

On the economic side of the garden six chains of new walk have been made. All the other walks have been widened and regravelled. The drains running under these walks have been bridged over with 2 inch planking, instead of with Rose-apple sticks as was the case formerly.

The drain that ran alongside the Liberian Coffee land has been filled up and another drain made four feet closer to the Liberian Coffee. By doing this I have been able to make the walk that runs parallel to the drain four feet wider so that it is now eight feet wide instead of four feet as before. There are now in the garden over two miles of walks to be looked after.

The usual attention has been given to the lawns and verges. The grass has been billed more times than usual. All the weeds have been taken out. Soil and manure has been supplied where needed, and the lawns are all in good condition.

Several old tree stumps and bamboo roots have been dug out.

The soil round many palms and trees on the lawn has been trenched and manured.

All the bends and borders have been well forked and manured, a large number of old shrubs have been dug out and young shrubs planted in their place. Some of the borders have had all the plants dug out, the land trenched and manured and young plants planted in the place of the old ones. One bed has been planted with Crotons and Hibiscus; these plants are very effective at the present time.

Most of the shrubs in the other borders have been transplanted.

The old worn out Crotons in the border to the north of the palmetum have been dug out, the land has been trenched, levelled, raked and planted out with Bahama grass, also a few palms and shrubs. Bright foliage plants have been planted about the tanks.

The pruning of trees and shrubs has been continued and has made a great improvement to the plants and the gardens generally. The trees had been planted much too close, and in places they had formed quite a block of vegetation, but by judicious thinning, several new vistas have been formed and the trees and shrubs are looking all the better for the extra light they are getting.

All the plants in the old rose garden have been taken up, the land trenched two feet deep, manured and planted with rose plants. These plants are now making good growth.

I have replanted two borders with rose plants. The roses have been planted in rows, one kind in a row. I have also planted roses on the economic side of the garden. Up to the present it has been a hard matter at Castleton to get rosewood for propagating. With the large number of roses planted out this year we should have plenty of rose-wood for propagating purposes.

There is not a very large variety of roses at these gardens, and more varieties are very much needed.

The old nursery was not only too small for the 30,000 plants of all kinds that we have to keep in stock, but it was too shady, and the ground too much on the slope, so that it was impossible to water the plants properly.

It was also very expensive to keep re-arranging the plants after heavy rains. To alter all this an acre of land was cleared and levelled on the economic side of the garden, and 600 ft. of 1 in. piping, 12 taps and 12 tanks were laid down so that the watering can be done easily. The new nursery is all that can be wished for, the land level, plenty of light and air, a fair amount of sun so as to make the plants hardy, plenty of room between each bed, and every facility for watering, potting, seed-beds, etc.

All the plants in bamboo pots have been removed to the new nursery, a new potting shed 30 ft. by 12 ft. has been erected so that we can now turn out 100,000 plants a year if wanted.

Up to the present the plants in the nursery have been put down anywhere, without any arrangement whatever. Now most of the plants are arranged alphabetically, and there is a place for every kind of plant we ought to have in stock.

The old nursery ground is being kept solely for plants in earthen pots, orchids, ferns and plants established, economic plants, vanilla,

black-pepper, inarching plants, plant houses and such plants that need daily attention.

Now that the second potting shed is erected, it gives ample room for potting, storage of pots, all kinds of soil, etc.

Two plant-sheds have been erected this year, one 30 ft. by 4 ft. and one 15 ft. by 4 ft., these make five plant-sheds and two potting sheds erected within the last two years.

A new roof has been put on the fern house and three more windows let in to allow more light, the staging repaired, refilled and painted, the path levelled and gravelled.

Among the purchases are new varieties of Orchids, Begonias, Caladiums, Cannas, Anthurium, Asparagus, Azaleas; they are all doing well except the two last.

I have introduced a new kind of label, made from one inch square cedar and 18 inches long planed all over, tarred nine inches at the lower part and painted white the upper part, this will be very effective and inexpensive.

A large number of orchids have been collected and established on trees in the gardens, also many native lilies and ground orchids have been collected and planted in beds about the gardens.

The Lily-tank has been emptied, new soil put in for the Victoria regia, and the small lilies repotted. I have planted three Victoria lilies in the tank instead of one lily as formerly, by planting three lilies we will get three times the amount of flowers, so that one flower should always be open in the season and there will always be plenty of good foliage in the tank. By taking away the leaves as soon as they are past their best, the tank should not get too full of foliage.

The small lilies have made a good show during the present year, but I am sorry to say they have not increased as I expected they would have done, so I have not been able to send out any young plants.

Young plants of Victoria regia have been sent for planting in the new tank at King's House Garden. Young plants of this lily have also been sent to several places in the Island, and a few planted in the still waters about the district.

The drought of this year was felt by the planters in the district; as far as the gardens were concerned it was good for them ; and on account of it several trees flowered and fruited which usually do not as the weather is generally wet in this district.

The value of the new tank has been demonstrated through the past drought by not having to carry water from the river as was the case in former years.

The old Liberian coffee trees continue to do well. The young plants that were planted 2½ years ago have flowered and fruited, the young trees are about four feet high.

The two new kinds of coffee, Coffea stenophylla, and the coffee from Abbeokuta are both making good growth, and C. stenophylla should soon fruit.

The plant of the Durian is quite established and making good growth.

The Imperial lemon trees have made good growth and a number of young plants have been produced from seeds and from inarching.

The rubber trees have made good growth the past year and I hope

soon to be able to send out a good number of plants. More young plants have been planted out.

The young plants of logwood, Durian, West Indian Dragons-blood, rubber tree are all doing well.

Half an acre of idle land between the cocoa ground and the walk has been cleaned, manured, trenched, drained and planted with such plants as ginger, arrowroot, cassava, cardamom, Liberian coffee seedlings, oranges, grape fruit, etc., etc.

Several large trees of oranges and lemons have been transplanted to more suitable places.

One thousand rough lemon plants received from the Hill Gardens and some thousands raised in the garden have been planted out to grow as stocks for budding.

Some of the plants of the Imperial Lemon raised by inarching have been sent to Hope and the Hill Gardens, and others planted out at Castleton as stock plants.

Piper nigrum.—Finding that the pepper plant had never fruited at Castleton, I have devoted attention to the plants during the last 18 months, and am pleased to say I have succeeded in fruiting two plants and have raised several young plants from the seeds gathered. I made several experiments and found out that the plants had been kept too shady.

The remainder of the palms that were not growing very well have had the soil about them trenched and manured, and they are all growing now in a satisfactory manner.

The old plants of Bertholletia excelsa that have been in such poor condition for years have taken another lease of life since the land they are on has been trenched. The plants are all making rapid growth, and the leaves that used to be as yellow as gamboge have now turned quite a dark green. I see no reason why they should not fruit in time.

Two of the Mangosteen trees have borne a good number of fruits; all the seeds we could get have been sown; I am sorry to say the seeds grow very slowly. I am raising plants of Garcinia Morella in the hope of being able to inarch the Mangosteen on them.

Common mangoes are being grown, on which to inarch East Indian Mangoes.

Eight fruits of the Coco-de-mer or Seychelle Palm have been received at the garden. Six of them have germinated and been planted out in suitable places on the economic side of the gardens.

Seeds of Borassus flabelliformis have also been received and planted out.

A quantity of Tree-ferns have been planted out in the border at the lower end of the Palmetum.

Between the economic side of the garden and the river the bush has been cleared for about two hundred yards. The clearance has made a great improvement in the landscape, as visitors can now see the water and the large creeper on the opposite side of the river and the hills beyond.

The bush has been cleared from 8 acres of land, some bamboos and native trees have been reserved and the land has been planted with

guinea grass, so that we can cut grass for the stock on the garden ground instead of the men having to go outside the gardens. 50 chains of fencing has been run to fence in the new land cleared.

The Public Works Department have run a fence around the new nursery to protect it from stock. They have also fixed a pipe to convey the water from the upper tank to the lily tank, run a wall on our side of the gutter that runs through the economic garden, painted and repaired part of the Superintendent's house and made two latrines for visitors.

Three 4ft. iron gates have been bought and fixed. About six more are needed. Wooden gates soon rot in this district as it is so wet.

PLANTS SOLD AT CASTLETON GARDENS.

Economic Plants :—		
Liberian Coffee	...	4,335
Kola	...	1,943
Manilla Hemp	...	256
Grape Fruit	...	120
Oranges	...	100
Rubber Plants	...	87
Miscellaneous	...	2,086
		8,927
Ornamental Plants	...	2,300
	Realising	£70 11s. 4d.
Plants sent to Hope :—		
Economic plants	...	2,794
Ornamental "	...	7,030
		9,824
Total number of Economic Plants Distributed		11,721
Total number of Ormamental Plants Distributed		9,330
Total number of Plants Distributed		21,051

Seeds Distributed :—50 quarts Liberian Coffee.
12 bags ditto
20 lbs. cured ditto

The elevation of the Garden is 580 feet above sea-level.

The average annual mean temperature is 76°. 2 F., and the average annual rainfall 110.01 inches. The amount of rain that fell during the year was 99.90 inches, being 10.11 inches below the average. September, October, November and December were the wettest months, and January, February, June and August the driest.

The mean temperature was 74° 9 F.

The Meteorological tables for the different months are given on page 06.

Hill Gardens.

The following Report is by Mr. Wm. Harris, Superintendent:—

Roads.—The main roads through the property were cleaned and kept in fair order.

Fences.—Necessary repairs were attended to, and the fences kept in good order. The Nursery was made secure by a substantial barbed wire fence.

Pastures.—These were billed and cleaned as usual during the year.

Garden.—The borders were thoroughly overhauled, trenched, manured, and the plants re-arranged. This became necessary through overcrowding, and through many of the specimens having become altogether too large for border plants. A large number of tree ferns were brought in and planted in the Arboretum. The walk through the Arboretum was re-made, considerably widened, and generally improved. The usual garden work, e.g. forking, manuring, weeding and raking, cutting grass, etc. was attended to as usual.

Nursery.—The propagation of garden plants has been attended to, and a stock sufficient to meet requirements has been kept on hand.

Blue Mountain Coffee.—Considerable difficulty is often experienced by Coffee planters in obtaining supplies of young coffee plants for supplying vacancies, or for planting up new land. To assist in this matter a quantity of the best Blue Mountain Coffee was procured for seed, and was sown. The plants, about 25,000 in number, were duly pricked out in prepared beds and they have made fair progress. The very dry weather experienced during the last three months of the official year affected them considerably, but they were shaded with fern fronds and are again looking well. Naturally, growth at this altitude (4,900 feet) is not so fast as it would be at a lower elevation, but it is thought that the plants will be hardier, and better suited for exposed situations than those raised at a lower altitude.

Orris Root. In the Annual Report for 1894 mention is made that seeds of Iris florentina and I. germanica were imported and sown. The plants raised are all apparently forms of the latter species. As expected they have grown luxuriantly, and during the latter part of the year under review many of them were lifted, the rhizomes cut off and the heads replanted.

For information on Orris-root see Bulletin for January 1896.

Orange Garden at Resource.

Resource is a property of 162 acres situated on the southern slopes of the Blue Mountains, about 9 miles from Gordon Town, and ranging in elevation from 3,400 feet to 4,000 feet. Parochial roads intersect the property, and as it is within half an hour's ride of Cinchona it has been placed under the Superintendent of that Establishment. As might be expected, an old property which had been out of cultivation for over a quarter of a century, save a few patches of provision ground worked by tenants and squatters, required a great deal of heavy work to restore it to something like order. There were no roads, no fences, and rank bush and large mango trees of useless sorts grew everywhere filling the land with roots and impoverishing the soil. These had to be renewed, the ground thoroughly dug up and immense quantities of roots and stones cleared away.

It is important that the ground for oranges should be thoroughly pulverised and carefully prepared; time is lost rather than gained by putting out plants in soil that has not been worked into condition suitable for their growth, and, moreover, they are likely to become diseased and stunted. The removal of stumps is not absolutely necessary, but renders subsequent culture much easier. In a word, everything is to be gained by careful cultivation at the start.

Work was commenced in the latter part of October 1895, by enclosing a portion of the land with a substantial wire fence. Since then 150 chains of wire fence have been erected. This fencing was necessary, as the property is surrounded on the east, south-east, south and west by small settlers, on the north and north-east by Coffee properties, and the Parochial roads passing through the property necessitated a good deal of extra fencing. As the cultivation extends, further fencing will be necessary. About 80 chains or 1 mile of roads have been made; mules have been purchased for the carriage of manure from Cinchona and other work; a small office for the use of the Superintendent, sheds for tools and for stock have been erected. The ground was cleaned and prepared for planting, and nearly 1,000 plants of all the best kinds of oranges, lemon, grape-fruit, shaddock, citron and lime have been planted out in permanent positions. These plants were obtained from England, Florida and California.

Seed beds on a very extensive scale have been specially prepared, and large quantities of Sweet orange, Sour orange, Lemon, Grape-fruit, Shaddock and Lime seeds sown.

During last orange season quantities of the best fruit procurable were purchased, and sufficient seeds sown to produce over 400,000 plants. The exceedingly dry weather experienced from the end of December 1896, to the end of March 1897, has retarded the growth of the young plants and although they were shaded and watered regularly they will not be ready for pricking out for some time yet. This work has to be very carefully done, and the plants have to be shaded and watered during dry weather till they again take good hold of the soil, then the beds must be weeded and kept clean.

The Sour oranges and Lemons are to form stock plants for budding, and this work is being carried on as quickly as the lemon and sour orange plants arrive at a suitable size. Already a large number of plants have been budded with the very best kinds of grape fruit, navel orange and choice shaddock, and many of these have been planted out in permanent positions. At present we have to depend on the generosity of owners of the best kinds of grape fruit and other trees for supplies of buds, but in a few years our own plants imported from England, Florida and California ought to be large enough to supply all the buds required; indeed this is what the plants were imported for.

In addition to the plants of the Citrus family about 150 fruit trees have been put out at Resource. These include Olives, Persian Grape vines; Figs, Peaches, Apples, Pears, Plums, Pomegranate, Mulberry, Loquat, etc. As there is plenty of land available, Resource should become a valuable property for experimenting with, and propagating fruit and other plants from sub-tropical and temperate climates, which would be likely to succeed at elevations from 2,000 feet upwards.

Sugar Canes.—Over 50 varieties of sugar cane from Hope Gardens have been planted to ascertain which are the most suitable for hill cultivation. The tops will be distributed free to settlers in the district who cultivate cane for making "new sugar."

West Indian Cedar.—About 55,000 plants of this tree were raised from seed, and the seedlings were duly transplanted and have grown splendidly. These are now being given away to anyone who applies for them. Already over 4,000 have been distributed. They have also been planted along our fences where they will in a few years not only clearly define our boundary lines, but will also become permanent fence posts, and effect a considerable annual saving on the renewal of posts. They will also materially increase the value of the property. A large number of Juniper Cedar plants are also being grown for distribution.

Green Manuring.—Quantities of seeds of Cow pea, Soja bean, hairy Vetch, Conga pea, Alfalfa, and other leguminous plants were sown through the cultivated portions of the ground to serve as green manuring, and to help to keep down the weeds that spring up everywhere after each shower of rain. It will take years of patient weeding and cultivation to thoroughly eradicate the weeds, which have had full sway here for over 25 years.

Fodder plants.—Various kinds of grasses and other fodder plants are under trial The Himalayan Grass grows most luxuriantly, and promises to be a great success.

Teosinte.—A packet of seed of this magnificent fodder plant was sown in April last. It produced stems ten feet high and flowered in October. Towards the end of October, half the area grown was cut and carefully weighed, when the yield was found to be at the rate of 44,000 lbs., or over 19½ tons of fodder per acre. Beyond being kept free from weeds when in a young state, the Teosinte received no special attention.

The plant is an annual, but readily reproduces itself on good land from the seed shed. If cut when young, but not too short, the stubble quickly springs again, and a second or even a third crop of green fodder may thus be obtained. The fodder is greatly relished by stock.

Bermuda Lily.—This beautiful lily is cultivated as a field crop in the Bermudas, to supply English and American growers with bulbs, and is a very remunerative industry. Mr A. H. Crane, an American who has recently settled in Jamaica, imported 40,000 young bulbs in the beginning of 1896. These were planted at Resource, being placed 8 inches apart in rows 18 inches asunder. The bulbs flowered all through the summer months, and were a noticeable feature at fully a distance of three miles from the field. The work of thoroughly cleaning and preparing the ground and planting the bulbs entailed considerable expense, which was borne by Mr. Crane.

In March, at the request of Mr. Crane, the bulbs in an average row were lifted and examined to see what progress, if any, had been made. There were originally 90 bulbs in this row, and when lifted and counted

these were found to have increased in number to 308. The bulbs were then sorted into sizes with the following results:—

4	bulbs,	3	inches in circumference
25	"	4	" " "
20	"	5	" " "
13	"	5½	" " "
20	"	6	" " "
9	"	6½	" " "
8	"	7	" " "
5	"	8	" " "
204	"	small, under 3 ins. in circumference.	
308			

Vegetables—Although attention has been devoted in the first place, and mainly to the cultivation and propagation of plants of the Citrus family, other products that are likely to prove useful are being tried on a small scale, when time and circumstances permit of this being done. This district is eminently suited during certain months of the year for the cultivation of European vegetables, and certain kinds are fairly well grown, but here, as elsewhere, the peasantry need practical lessons on the best methods of cultivation. With this object in view, as well as to test the capabilities of the soil, a few vegetables have been grown—cabbages, turnips, carrots, beet, leeks, peas, potatoes, tomatoes, cucumbers, marrows.

One pound of potatoes yielded 40lbs. of good tubers; tomatoes yield abundant crops of handsome well flavoured fruits; splendid marrows were produced in less than a month from date of sowing seed, and cucumbers in two months; cabbages form excellent heads, large and firm, and all the other kinds grown have been most successful. The seeds of tomato, etc., are given to any of the settlers who ask for them.

The following special experiment in potato cultivation was carried out, but, for the reasons stated was not altogether a success, and similar experiments carried out in different parts of the Island about the same time were, generally, even less successful.

Report on Potato Experiment.

We received one barrel of Potatoes from Mr. Douet in October 1896. They were apparently fine potatoes for cooking purposes, but not at all what are known as "seed potatoes". They were too large and evidently had not been allowed to remain in the ground long enough to ripen, and consequently the eyes were immature, and unable to make good strong growths. Then again, many of the large tubers, when cut, were found to be quite hollow and useless, 40lbs in weight being in this state.

The potatoes were kept till the middle of November, and as they were then showing signs of growth the sets were prepared, and on the 20th of November they were planted at Resource, at an elevation of 3,600 feet, the ground having previously been well dug and manured. The soil I may mention is a gravelly loam.

Mode of Planting. The sets were planted in trenches 2½ feet apart, and a space of 15 inches was allowed between the sets in the trenches.

Subsequent culture. The ground was kept free from weeds whilst the potatoes were growing, and the plants were moulded twice.

Lifting.—The potatoes were taken up on the 1st March, 1897, so that they were in the ground exactly 100 days, or a little over 3 months.

Weather.—"Seasonable" weather prevailed from time of planting to 29th December, or 39 days, and from then till date of lifting the crop no rain was registered, a period of 61 days, or two months.

Yield.—The total weight of potatoes lifted was 360lbs.; of these 215lbs. were of marketable size, and small tubers suitable for seed 145lbs. The marketable potatoes were of good quality and were sold at the rate of 12/6 per 100lbs.

The following is a Statement of Receipts and Expenditure:—

Receipts—

215lbs. potataes at 12/6 per 100lbs.	...	£1	6	$10\frac{1}{2}$				
145lbs, seed at say $\frac{1}{2}$d. per lb.	...	0	6	$0\frac{1}{2}$		£1	12	11

Expenditure—

Cleaning and preparing ground	...	0	7	6			
Manure, valued at	...	0	5	0			
1brl. of potatoes	...	0	8	6			
Planting	...	0	2	6			
Moulding and weeding	...	0	2	6			
Lifting	...	0	1	6	1	7	6
Net profit	...		...		£0	5	5

This shows a profit of 5/5 on the transaction, which would not pay for the trouble, but there is little doubt that with good seed, and a favourable season, excellent results might be obtained.

Plants Distributed.—Sold.

Economic Plants:—

Sweet Oranges	...	11,639
Sour Oranges	...	2,500
Grape Fruit	...	4,150
Shaddock and Limes	...	58
Ornamental plants	...	506

Free Grants.

Tea Plants	...	16,055
W. I. Cedar	...	4,425
Other Economic Plants	...	447
Ornamental—various	...	287
Total Economic plants distributed		39,274
Total Ornamental plants distributed		893
Total number af plants distributed		40,167

The following seeds were also distributed:—

28lbs of Tea seed.

18,000 Rough Lemon Seeds.

and of Tree Tomatoes, 217 dozens weighing 434lbs.

The elevation of the Hill Garden House where the instruments are placed is 4,907 above sea-level.

The average mean temperature there is 62°9 F. and the average annual rainfall 105.04 inches for 26 years.

The amount of rain that fell during the year was 80.98 inches or 10.40 inches below the average.

September, October, November and December were the wettest months, and January, February and March were the driest.

The mean temperature was 62° ·4 Fah. The Meteorological tables for the different months are given on page 305. The rainfall at the Orange Garden, Resource, was 45.63 inches for the year; May, October and November were the wettest months, and June, January and February the driest. During the two latter months, and the first half of March, no rain was registered.

KINGSTON PUBLIC GARDEN.

The following Report is by Mr. J. Campbell, Superintendent :—

The general work of the Garden during the past year has been strictly attended to in weeding forking, pruning, trimming, edging, clearing away of rubbish, manuring and watering; the last item had to be done almost incessantly, on account of the protracted drought of about eight months. It is with difficulty that the cut edges can be kept in good order on account of the continual trampling by the people who will not keep to the pathway.

I may mention that the outer borders around the Garden are crowded with too many trees of large growth which are now becoming developed. It would be well to take away a few of these alternately so as to allow the shrubs and flowering plants to thrive, and this would improve the appearance of the Garden.

A few of the Ficus lucida trees have died out this year, especially those that are fully grown; every care was taken to save the trees as soon as they showed the first sign of decay by application of fertilisers, etc. It is noted that several trees of this kind about Kingston have died out during the past year.

The garden benches have been repaired and painted.

The walks require gravelling, but this item of expenditure was sometime ago taken off the vote. I would suggest that it be renewed. The bridges require repairing. The dung pit enclosure requires repairing.

I would suggest the removing of the Kiosk from the Garden, as it is becoming quite a nuisance to the Garden. The person in charge of it does not confine himself to it, but allows refuse to be thrown in the Garden, and allows all sorts of utensils, barrels, boxes, handcarts, etc., which he uses in his trade to lie about, cooking with a large stove and kerosene tin in the Garden, and using the tank for washing all sorts of dirt. I have repeatedly remonstrated with the man, but it is useless. I may say that what he sells, visitors can be easily accomodated with at the gates.

It would be necessary to have on band evenings more police supervision. The infringements of the Garden regulations have been dealt with at the Police Court. I may state that the amount alotted for the up-keep of the Garden is inadequate to the requirements.

The elevation of the Garden above sea-level is 60 feet.

The average annual mean temperature is 79°.0 F., and the average annual rainfall 34.73 inches for 27 years.

The amount of rain that fell during the year was 15.07 inches.

The mean temperature was 79°.9 F. The Meteorological Tables for the different months are given on page 309.

Bath Garden.

The following Report is by Mr. A. H. Groves, Overseer of Bath Garden :—

I am glad to report that this garden is in fair order, and this is chiefly owing to the supply of water from the well, as indeed, if it were not for this supply, many of the plants and trees would have suffered seriously, as also many of the inhabitants of the Town of Bath for want of proper drinking water.

Fearfully dry weather prevails, rivers dried up, and the small lots of water quite unfit for drinking purposes.

At the same time I find that although the well is near at hand, it costs from 5s. to 6s. per day to supply water at this season of the year. I would therefore ask if it would not be economy to furnish a small pump and hose, say, about 200 feet. If the Government will consent to supply these articles, it will be a great saving in labour, and also a convenience.

I have supplied, as per vouchers, a grindstone and tools for the Garden.

The walks have been regravelled, the trenches cleaned out, and the greater part of the garden forked.

I find the wire fence requires to be looked to, as many of the droppers are entirely rotten from rust. I intend to have them replaced by those on hand, and have them painted by the end of the next quarter.

Elevation of the Garden above sea level 170 feet. Mean temperature 78° Fah.

King's House Garden.

The following Report is by Mr. T. J. Harris, Assistant Superintendent.

In the course of the year several improvements have been made in the Garden, such as the contruction of a spacious tank for the giant water-lily (Victoria regia,) the cleaning away of tangled masses of shrubs and climbers which formed a dense belt around the north side of the Garden, the opening up of vistas, and the planting of a large portion of the enclosed garden with Bahama grass. A border running south-west from the ball-room has been laid out and planted with miscellaneous shrubs, which are doing fairly well notwithstanding the fact that the soil is only two inches deep in that part of the garden.

Several large trees have been felled, including a large Mahogany and three large Mangoes; this was found necessary when opening up views in the garden.

A large Ficus immediately in front of the Bungalow died and had to be removed; the ground was afterwards well dug and manured, and planted with flowering shrubs and a Cassia siamea to replace the defunct Ficus.

In the Guinea-grass piece between the Bungalow and the stables, a dozen or so large trees were felled and the stumps grubbed out and

cleared away; a large number of stumps were also grubbed out of the new grass piece at the back of the stables.

The pastures have had the usual cleaning, and the fences have been kept in good repair, and the gates have lately been rehung and tarred.

The mule-paddock has been billed out as it became necessary as also have the plots of cleared ground at the back of King's House and near the stables; the roads too have had the usual hoeing and cleaning, and repairing where necessary.

Two plants of Beaumontia grandiflora obtained from Hope Gardens have been planted near the west lodge and are doing well; a large pod of seed ripened on an old plant in the fernery and was sent to Hope.

The Victoria regia was planted on January 1st but apparently no time would have been lost if the planting had been deferred until the beginning of April; around the outside of the tank the pretty little Ficus repens has been planted and is commencing to climb up the wall. The overflow has been led out to a convenient place in the lawn, where a pond will be formed for the cultivation of different aquatic and semi-aquatic plants.

Most of the Orchids have been repotted or rebasketted and are doing well; the decorative plants in pots have also been treated as found necessary. The weeding, rolling, mowing, and watering of the lawns have been regularly attended to, and the task of repairing the walks and verges has been proceeded with as opportunity offered.

About two acres of the enclosed garden remain to be ploughed up and planted with Bahama grass, and this, no doubt will be accomplished during the coming year.

A group of the Mountain Pride (Spathelia simplex) has been planted in the lawn near the outer walk and is doing well; these when in flower will have a striking effect in the landscape.

The walks and lawns have been regularly cleaned and tidied up, rubbish carted away, manure collected as soon as available, pot plants attended to in house and nursery, flowers gathered and decorations carried out in both ball and dining rooms, and the innumerable details inseparable from the routine of a well-kept garden have been strictly supervised.

I may add that the need of more glass accommodation for the proper cultivation of delicate plants such as Orchids, etc. is daily becoming more apparent; and that a small building equivalent to the English "bothy" is badly needed for a few of the regular employees, as at present the Superintendent is compelled to give up his servants' quarters for this purpose.

The elevation of the Garden above sea-level is 400 feet.

The average mean annual temperature is 78°.5 F. and the average annual rainfall 47.24 inches for 17 years. The amount of rain that fell during the year was 30.69 inches being 16.06 inches below the average. September, October, and November, were the wettest months, and January, February andMarch the driest.

The mean temperature was 76°.9. The meteorological tables for the different months are given on page 308.

METEOROLOGICAL TABLES.

HILL GARDENS.

Month.	Bellevue.—Elevation 4,907 feet. Pressure. 7 a.m.	Pressure. 3 p.m.	Temperature—Degrees. 7 a.m.	Temperature 3 p.m.	Temperature Max.	Temperature Min.	Temperature Range.	6 Feet Under Ground. 7 a.m.	6 Feet Under Ground. 3 p.m.	Dew Point. 7 a.m.	Dew Point. 3 p.m.	Humidity. 7 a.m.	Humidity. 3 p.m.	Wind. Direction.	Wind. Force—Miles.	Rainfall—Inches.	Resource—Elevation 3,700 feet.	Rainfall—Inches.	
1896.	Ins.	Ins.	°	°	°	°	°	°	°	°	°								
April ...	25.362	25.349	57.7	62.4	65.6	53.5	12.1	61.0	61.0	52.5	59.2	83	89	E	43.1	6.21	...	2.03	...
May ...	.351	.343	61.1	63.9	67.7	55.1	12.6	61 0	61.0	56.2	61.1	83	90	E	9.3	8.25	...	6.30	...
June ...	.387	.387	63.1	68.0	70.7	58.0	12.7	61.6	61.6	57.5	61.9	83	81	E	34.6	4.00	...	1.00	...
July ...	.414	.404	62.6	67.7	71.2	59.2	12.0	63.3	63.2	57.4	61.6	80	81	S E	35.1	4.21	...	2.43	...
August ...	.399	.426	63.5	67.7	72 2	59.4	12.8	64.1	64.2	57.0	61.4	78	78	S E	20.3	0.76	...	4.10	...
September ...	.334	.321	63.0	66.5	70.1	58.6	11.5	64.0	64.0	59.3	63.6	86	90	S E	15.1	10.79	...	5.72	...
October ...	.341	.320	62.5	65.2	69 7	58.5	11.2	63.0	63.0	58.9	63.3	86	93	S E	13.5	17.83	...	9.30	...
November ...	.331	.316	59.8	63 9	67.9	56.4	11.5	63.0	63.0	55.4	59.8	83	86	E	42.8	13.21	...	8.10	...
December ...	.349	.338	58.8	63.3	66.5	56.0	10.5	62.1	62 1	56.1	61.4	89	93	E	46.7	12.71	...	5.50	...
1897.																			
January ...	.350	.343	54.1	62.2	65.8	51.1	14.7	62.0	62.0	47.7	56.9	80	83	E	28.6	1.72	...	0.00	...
February ...	.381	.371	56.0	64.8	68.9	53.5	15.4	62.0	62.0	49.9	59.3	80	81	E	25.0	0.23	...	0.00	...
March ...	.363	.355	57.0	65.4	69.0	54.2	14.8	62.0	62.0	51.6	59.2	83	81	E	30.3	1.06	...	1.15	...
Means ...	25.363	25.356	59.9	65.0	68.7	56.1	12.6	62.4	62.4	54.9	60.7	82	85	E	28.7	80.98	...	45.63	...
					Mean 62.4														

Castleton Gardens—Elevation, 580 Feet.

Month.		Pressure		Temperature. Degrees Fahrenheit.					Dew Point.		Humidity.		Rainfall—Inches.
		7 a.m.	3 p.m.	7 a.m.	3 p.m.	Max.	Min.	Range.	7 a.m.	3 p.m.	7 a.m.	3 p.m.	
1896.		In.	In.	°	°	°	°	°	°	°			
April	...	29.62	29.62	68 1	78.9	82.8	63.1	19.7	65.0	69.7	93	74	5.43
May	...	.59	.58	71.2	79.9	84.6	66 3	18.3	68.9	73.1	93	79	9.64
June	...	.61	.60	74.3	85.3	88.8	67.1	21.7	70.3	72.4	87	65	3.71
July	...	.64	.63	73.6	84.4	88.7	67.7	21.0	69.0	71.0	87	63	4 33
August	...	.62	.62	71.9	84.4	89.1	66.5	22.6	69 1	71.4	90	65	3.46
September	...	.54	.50	74.3	82.8	88.3	67.1	21.2	71.3	74.7	90	76	11.14
October	...	.52	.52	71.4	80.3	87.8	66.2	21.6	70.6	73.7	97	82	20.09
November	...	.57	.55	70.3	79.2	84.5	65.3	19.2	68 7	72.4	96	76	16.24
December	...	.60	.59	69.3	78.1	81.7	65.0	16 7	68.4	71.5	96	81	18.79
1897.													
January	...	.62	.61	64.0	76.9	80.0	58 2	21.8	62.5	66.5	96	71	1.81
February	...	.65	.63	62.9	81.4	85.4	59.2	26.2	62.1	69.9	96	67	0.60
March	...	.63	.62	66.1	80.8	84.9	61.0	23 9	64.6	70.2	96	67	4.66
Means	...	29.60	29.58	69.7	81.0	85.5	64.3	21.2	67.5	71.3	93	72	99.90
						Mean 74.9							

Hope Gardens—Elevation 700 Feet.

Month.		Pressure. 7 a. m.	Pressure. 3 p. m.	Temperature. Degrees Fahrenheit. 7 a. m.	Temperature. Degrees Fahrenheit. 3 a. m.	Temperature. Degrees Fahrenheit. Max.	Temperature. Degrees Fahrenheit. Min.	Temperature. Degrees Fahrenheit. Range.	Dew Point. 7 a. m.	Dew Point. 3 p. m.	Humidity. 7 a. m.	Humidity. 3 p. m.	Rainfall—Inches.
1896.		In.	In.	°	°	°	°	°	°	°			
April	...	29.25	29.26	68.2	79.3	83.4	64.3	19.1	66.0	75.5	93	90	3.48
May	...	.25	.26	70.3	81.6	86.7	66.4	20.3	68.1	77.7	93	87	5.18
June	...	.27	.28	76.3	87.2	90.2	69.5	20.7	73.7	81.2	93	82	0.89
July	...	.28	.29	74.7	86.3	90.0	70.6	19.4	69.5	73.4	84	65	2.19
August	...	.26	.28	74.4	84.5	90.1	70.4	19.7	67.4	72.3	78	65	1.19
September	...	.19	.19	74.4	83.3	89.3	70.6	18.7	69.5	75.6	87	79	7.08
October	...	.19	.19	73.6	82.8	89.7	69.4	20.3	69.1	73.6	84	74	3.09
November	...	.20	.21	71.3	82.5	87.9	67.9	20.0	65.7	72.9	82	71	4.91
December	...	.25	.25	69.7	81.6	85.1	63.6	21.5	67.0	70.9	90	69	2.82
1897.													
January	...	.28	.28	64.6	82.8	88.6	60.9	27.7	58.2	72.9	78	71	0.00
February	.	.29	.29	68.8	85.5	89.1	64.7	24.4	63.4	70.3	81	59	0.00
March	...	.26	.26	68.7	84.1	88.6	65.0	23.6	63.8	73.4	84	69	0.65
Means	...	29 24	29.25	71.2	83.4	88.2	66.9	21.3	66.8	74.1	85	73	31.48
						Mean 77.5							

Kings House Garden.—Elevation, 400 feet.

Month.	Pressure. 7 a.m.	Pressure. 3 p.m.	Temperature. Degrees Fahrenheit. 7 a.m.	3 p.m.	Max.	Min.	Range.	Dew Point. 7 a.m.	Dew Point. 3 p.m.	Humidity. 7 a.m.	Humidity. 3 p.m.	Rainfall—Inches.
1896.	In.	In.	°	°	°	°	°	°	°	°	°	
April ...	29.87	29.84	69.9	86.0	89.9	62.0	27.9	65.4	73.9	84	64	1.20
May ...	.86	.84	73.1	83.9	86.5	64.9	21.6	69.9	74 2	90	72	6.40
June ...	.87	.82	74.8	87.3	91.4	66.5	24.9	70.1	75.6	84	69	0 79
July ...	.91	.84	74.1	87.2	92.9	66.7	26.2	70.2	75.0	87	67	2.45
August ...	.82	.76	73.8	86.7	91.8	65.7	26.1	70.3	75.7	87	69	2.10
September ...	...	...	73.8	83.2	91.6	66.8	24.8	66.0	71.3	76	67	5.35
October ...	...	...	73.6	85.5	91.0	65.8	25.2	70.6	77.5	90	77	4.30
November ...	...	...	70.4	85.0	88.1	62.7	25.4	65.9	74.7	87	72	5.03
December ...	...	...	70.5	83.5	87.7	63.0	24.7	66.2	72.2	86	68	2.47
1897.												
January ...	...	...	66.4	83.5	87.8	59.2	28.6	62.4	73.2	87	69	0.19
February ...	...	...	67.5	86.5	90.8	61.7	29.1	63.0	71.4	84	59	0.00
March ...	...	...	68.7	86.2	90.4	62.8	27.6	64.4	68.7	84	57	0.41
Means ...	29.86	29.81	71.3	85.3	89.9	63.9	26.0	67.0	73.6	85	67	30.69
	For 5 Months.				Mean 76.9							

KINGSTON PUBLIC GARDEN.—Elevation 60 feet.

Month.	Pressure.		Temperature. Degrees—Fahrenheit.					Dew Point.		Humidity.		Wind.		Rainfall—Inches.
	7 a. m.	3 p. m.	7 a. m.	3 p. m.	Max.	Min.	Range.	7 a. m.	3 p. m.	7 a.m.	3 p.m.	Direction.	Force—Miles.	
1896.	In.	In.	°	°	°	°	°	°	°					
April ...	29.997	29.954	71.8	83.3	86.4	69.1	17.3	65.6	68.4	81	61	SSE	83.0	0.86
May ...	29.937	29.885	76.3	83.3	86.6	72.4	14.2	69.1	71.0	79	68	SE	81.8	4.34
June ...	29.954	29.941	79.8	87.1	89.0	75.3	13.7	70.1	70.1	73	59	SE	124.0	0.90
July ...	29.979	29.954	78.5	86.8	89.8	74.4	15.4	69.7	71.1	75	60	SE	105.4	0.99
August ...	29.948	29.935	76.6	86.4	90.7	74.1	16.6	69.1	72.2	78	63	SE	81.1	0.40
September ...	29.862	29.867	76.4	85.6	89.1	74.8	14.3	71.6	74.2	83	69	SE	70.9	2.92
October ...	29.884	29.868	75.6	85.9	89.7	74.1	15.6	70.7	73.9	85	68	SE	67.1	0.97
November ...	29.893	29.863	72.9	86.0	88.9	71.6	17.3	67.7	70.0	83	59	SE	67.4	1.40
December ...	29.930	29.945	72.3	84.1	87.6	71.0	16.6	67.4	70.0	85	63	SSE	76.1	2.14
1897.														
January ...	29.973	29.956	68.2	82.7	85.7	66.6	19.1	60.5	64.7	77	55	SSE	92.7	0.02
February ...	29.985	29.987	70.5	84.6	87.5	68.9	18.6	63.1	68.4	77	59	SSE	107.1	0.00
March ...	29.964	29.948	71.4	84.5	86.4	69.6	16.8	64.9	68.2	81	59	SSE	89.4	0.13
Means ...	29.942	29.927	74.1	85.0	88.1	71.8	16.2	67.4	70.1	79.7	61.9	SE	87.1	15.07
					Mean 79.9									

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